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Station

Red River Waterway, John H. Overton Lock and Dam

Report 3
Sedimentation Conditions
Hydraulic Model Investigation

by Randy A. McCollum

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Prepared for U.S. Army Engineer District, Vicksburg

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Report 3 of a Series

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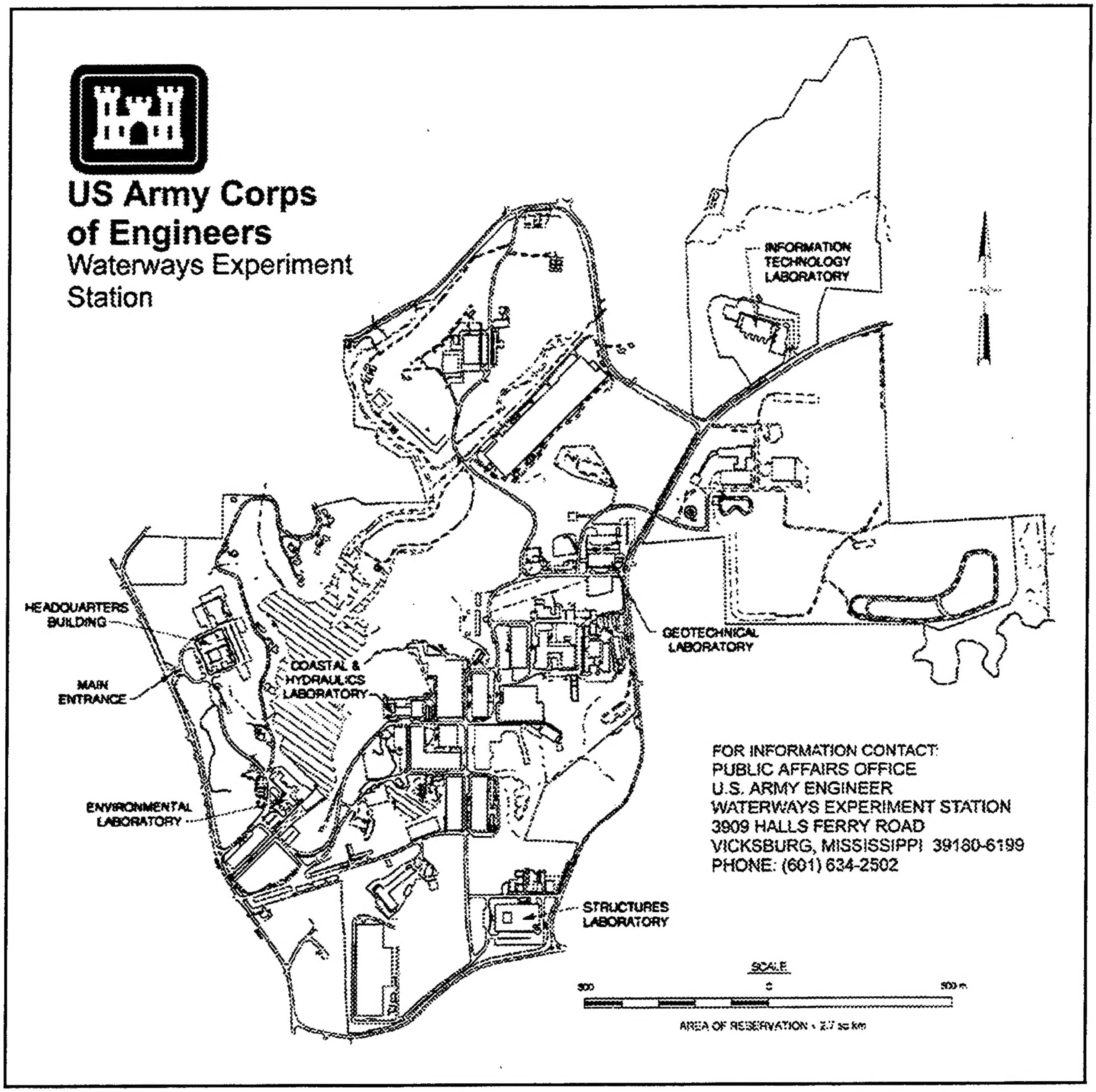

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Contents

Preface

The model investigation reported herein was conducted for the U.S. Army Engineer District, New Orleans (LMN), and the U.S. Army Engineer District, Vicksburg (LMK), by the U.S. Army Engineer Waterways Experiment Station (WES) during the period March 1978 to December 1987.

In addition to the hydraulic movable-bed model study, two physical model studies and two numerical model studies were conducted at WES. The additional studies included a fixed-bed navigation model study (Report 2); a hydraulic structures model study (Report 4); a numerical model sedimentation study of upstream and downstream approaches to Lock and Dam No. 4 (Report 5); and a numerical model sedimentation study of the Red River upstream and downstream of Lock and Dam No. 4 (Report 6). This is Report 3 of the series. Report 1, to be published later, will summarize all of the model studies.

The investigation was conducted in the WES Hydraulics Laboratory under the general supervision of Mr. F. A. Herrmann, Jr., Director of the Hydraulics Laboratory. The engineer in immediate charge of the model study was Mr. C. W. O'Neal, Chief of the River Regulation Branch, Waterways Division, Hydraulics Laboratory. He was assisted by Mr. D. N. Mobley. This report was prepared by Mr. Randy A. McCollum assisted by Mmes. Donna Derrick and Margaret Edris, all of the Navigation Division, Coastal and Hydraulics Laboratory.

During the course of the model study, representatives from Headquarters, U. S. Army Corps of Engineers; U. S. Army Engineer Division, Lower Mississippi Valley; LMN; and LMK visited WES to observe model tests and discuss test results. LMN, then LMK (after receiving project authority), was kept informed of the progress of the study through monthly progress reports and periodic transmittal of preliminary test results.

This report is being published by the WES Coastal and Hydraulics Laboratory (CHL). The CHL was formed in October 1996 with the merger of the WES Coastal Engineering Research Center and Hydraulics Laboratory. Dr. James R. Houston is the Director of the CHL, and Messrs. Richard A. Sager and Charles C. Calhoun, Jr., are Assistant Directors.

During publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
degrees (angle)	0.01745329	radians
feet	0.3048	meters
miles (U.S. statute)	1.609344	kilometers

1 Introduction

Location and Description of Prototype

The Red River flows easterly from the northwest portion of Texas along the border between Texas and Oklahoma through southwestern Arkansas into northwestern Louisiana then southeasterly to join the Old River and form the Atchafalaya River (Figure 1). Flow in the upper portion of the Red River is controlled by releases from Denison Dam, which is located on the Texas-Oklahoma state line. Flow from the Mississippi River through Old River Diversion Channel into the Atchafalaya River has considerable backwater effect on upstream stages including the lower Red River. A 75- by 1,200-ft[1] lock at the mouth of Old River provides for navigation between the Mississippi, Red, and Atchafalaya Rivers.

The Red River has large fluctuations in stage, shifting bed, caving banks, and unpredictable shoaling. The controlling depths in the Red River have averaged about 6 ft from the mouth to Alexandria, LA, and about 5 ft from Alexandria to Shreveport, LA, from January to July and generally less the remainder of the year. The controlling depth during some periods is as low as 1 to 2 ft in the Alexandria to Shreveport reach. The use of the Red River for movement of cargo by barges has been limited because of long periods of low flows, narrow bends of short radii, and a heavy sediment load.

Plan of Development

Public Law 90-483, enacted by the 90th Congress on 13 August 1968, authorized the Red River Waterway Project. The project is authorized to improve the Red River and its tributaries in Louisiana, Arkansas, Texas, and Oklahoma through coordinated development to serve navigation, bank stabilization, flood control, recreation, fish and wildlife, and water quality control. The navigation reach is intended to establish a 9-ft-deep by 200-ft-wide navigation channel,

[1] A table of factors for converting non-SI units of measure to SI units is found on page vi.

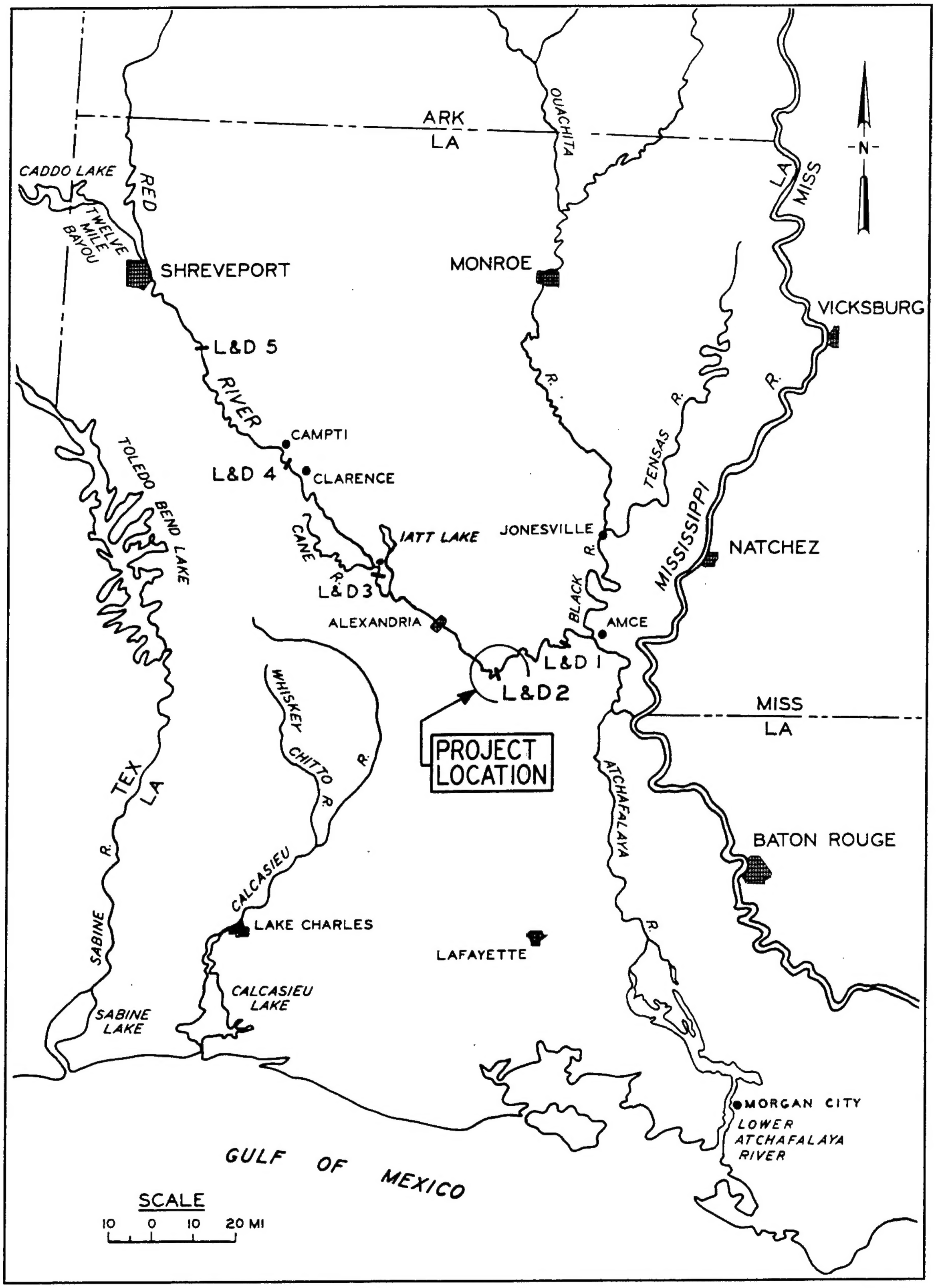

Figure 1. Location map

approximately 305 miles long, from Old River to Lake O' the Pines near Daingerfield, TX, by a system of nine locks and dams, a number of cutoffs, extensive channel realignment, and channel training and stabilization works. There are four distinct reaches: (a) Mississippi River to Shreveport; (b) Shreveport to Daingerfield, by Twelve Mile Bayou; (c) Shreveport to Index, AR; and (d) Index to Denison Dam, Texas. The Appropriations Act of 1971, approved 7 October 1970 as Public Law 91-439, provided authority to initiate preconstruction planning in the Mississippi River to Shreveport reach, the only reach pertinent to this study.

John H. Overton Lock and Dam

John H. Overton Lock and Dam is located in a cutoff channel between 1967 river miles 89.0 and 86.5 (Figure 1). John H. Overton Lock and Dam, the second navigation structure on the Red River, consists of a lock on the left side of the cutoff channel and a dam on the right side. The lock has a usable chamber 84 ft wide by 685 ft long with an upper sill to el 40.5[1], a floor to el 23, a lower sill to el 25, and lock walls to el 74.5. The dam is 348 ft long with five 60-ft-wide gates, six 8-ft-wide piers, a sill at el 28, and stilling basin at el 12. The dam was designed to maintain a normal pool at el 64 upstream to Lock and Dam 3 and to pass the project flood flow of 225,000 cfs.

Purpose of Study

The general design of John H. Overton Lock and Dam was based on sound theoretical design practice and experience with similar structures; however, the navigation conditions and channel development problems are site-specific and not amenable to analytic solution. Since John H. Overton Lock and Dam was constructed in an excavated channel bypassing a 2-1/2-mile bend, unusual problems were expected, especially as there were no existing flow conditions to use as a guide. Therefore, a hydraulic model study with provision for movable-bed operations was necessary to (a) determine the sedimentation conditions in the upper and lower pools and (b) help determine solutions to any adverse conditions found. The purposes of the model study were as follows:

a. To study tendency for scour and fill in the approaches to the lock and dam.

b Determine training structures that would improve navigation conditions and minimize dredging requirements and scour problems.

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[1] All elevations (el) cited are in feet referred to the National Geodetic Vertical Datum (NGVD).

2 The Model

Description

A model reproducing a reach of the Red River from 1967 river miles 90.0 to 85.0 was designed for movable-bed operations and built to linear scale ratios of 1:120 horizontally and 1:80 vertically (Plate 1). The upstream and downstream dimensions of the dam were constructed to the vertical scale to more nearly reproduce the hydraulic characteristics of the dam. Overbank areas were molded of sand-cement mortar, and the bed was molded in crushed coal using the fixed top bank elevation as a reference. The crushed coal had a median diameter of 4 mm and a specific gravity of 1.30. Dikes were molded of crushed stone. Folded strips of wire mesh were used to simulate the roughness effects of trees and underbrush on the overbank areas. The lock and dam were fabricated of sheet metal. Dam and lock gates were simulated with simple sheet-metal slide-type gates.

The overbank portion of the model was molded to a combination of contours and elevations shown on the following: Red River, Louisiana, Hydrographic Survey of March 1968; the U.S. Geological Survey (USGS) quadrangle sheets dated 1960; the Whittington Revetment Survey, September 1976; and the Hog Lake Revetment Survey, April 1975. The channel portion was molded to a hydrographic survey dated March 1968 (Plate 2). The proposed cutoff and the lock and dam were installed according to plans furnished by the U.S. Army Engineer District, New Orleans.

Appurtenances

Water was supplied to the model by a 10-cfs axial flow pump operating in a circulating system and was measured at the model's upstream end by two venturi meters of different sizes for accurate flow measurement over the range of discharges to be reproduced. Water-surface elevations were measured at 6 model gauging stations by 6 piezometers (11 piezometers total after installation of lock and dam) located in the model channel and connected to a centrally located gauge pit (Plate 1). An adjustable tailgate was provided at the downstream end of the model to control the water-surface elevation during model adjustment. During

model runs the upper pool water-surface elevation was controlled by manipulating the dam gates. For uncontrolled flows, the gates were completely removed from the water. All gates were opened equally for each run. The tailgate at the downstream end of the model controlled the lower pool water-surface elevation. A graduated container measured the bed material introduced at the upstream end of the model. A sediment trap was provided at the downstream end of the model where material discharged could accumulate and be measured at the end of any specific period. Sheet-metal templates were used for molding the model bed before certain runs. A carefully graded rail was installed along each side of the channel to (a) support the templates at the correct elevations; (b) support a rail used to survey the model bed; and (c) provide vertical control for installing structures in the model.

Model Adjustment

The bed and bars of movable-bed models are composed of material capable of being transported as bed load. Bank lines are normally fixed unless caving banks are expected to have a major impact on the study. Fixed bank lines and a coal bed were used in this study. Before a movable-bed model can examine the effectiveness of proposed improvement plans, its ability to reproduce conditions similar to those expected in the prototype must be demonstrated. Complete agreement between model and prototype is seldom obtained because of the inherent distortions incorporated in the model design and the operation of the model. Due to these dissimilarities, reliability for this model type cannot be fully established by mathematical analysis and must be based on model adjustment. Model adjustment involves the modification of various hydraulic forces, time scale, rate of introducing bed material, and model operating techniques until the model reproduces, with acceptable accuracy, the changes known to have occurred in the prototype during a given period. Various scale relationships and model operation procedures established during model adjustment are used in examinations of various improvement plans. The degree of similarity between model and prototype data obtained during model adjustment is considered in the analysis of model examination data.

Adjustment Procedure

A normal adjustment of a movable-bed model requires (a) two prototype bed surveys about one year apart (to provide a full range of discharges) and (b) the stages and discharges that occurred in the study reach between the surveys. For the study reach, only one survey was available, a March 1968 hydrographic survey (Plate 2). The model bed was molded to the 1968 survey. The hydrograph (discharge and stage) for the year prior to the survey (March 1967-March 1968) was reproduced in the model (Plate 3). The model was controlled so that the

stages in the center of the model agreed with the stages that occurred in the prototype for the period. Bed material was introduced at the upper end of the model with each flow. At the end of the period, the model bed was surveyed, and those bed configurations were compared with the prototype survey. If the model did not reproduce the prototype survey closely enough, the process was repeated with modifications to the time and discharge scales, the rate of introduction of bed material, bed slope, and model operating techniques. This process was repeated until the model satisfactorily reproduced the prototype bed configurations. Once the model was adjusted, the scales and procedures were used in the experiments. It should be noted that herein each repetition of a hydrograph will be referred to as a run.

The model adjustment results indicated that the model satisfactorily reproduced the prototype bed configurations (Plate 4). The model did not exactly reproduce each area of the model, but the general trends of the model to scour and fill are very similar to the prototype survey (compare Plates 2 and 4). The differences noted between the model and the prototype were considered when each model condition was evaluated.

3 Experiments and Results

Plan A

Description

Upon completion of adjustment, the bypass channel from mile 89.0 to 86.5 was opened and a cutoff structure placed in the old channel at mile 88.7. The proposed design of the lock, dam, excavated bank lines, and revetments was modified from the original design specified in Design Memorandum No. 7, dated November 1977[1]. The initial plan examined was Plan D-modified, developed in the fixed-bed model study[2] of the same reach, with the following exceptions: changing the dam from seven gates to six 60-ft gates, modifying the transition in the downstream lock approach, and making the downstream landside guide wall solid. The original design maintained an upper pool at el 58 (later changed to el 64 after reformulation). The 1972 typical water year hydrograph (Plate 5) was used in the research. The initial plan as installed in the model is shown in Plate 6. For Plan A-4, the right bank lines upstream and downstream of the dam were modified to match those of Plan E (fixed-bed study). As the study progressed, various modifications were made to improve the sediment deposition patterns in the lower lock approach and channel.

Results

A survey of the first run with Plan A is shown in Plate 7. During research using Plan A, a total of 23 modifications were made to the original plan. Plan A-23 was run with two repetitions of the 1972 average water year hydrograph, two repetitions of the 1971 low water year hydrograph (Plate 8), and one repetition of the 1958 high water year hydrograph (Plate 9). The survey

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[1] U. S. Army Engineer District, New Orleans, (1977). "Hydrology and hydraulic design, John H. Overton Lock and Dam," Red River Waterway, Design Memorandum No. 7, New Orleans, LA.

[2] L. J. Shows and John J. Franco, (1979). "Navigation conditions at John H. Overton Lock and Dam," Technical Report HL-79-3, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

taken after the final repetition of each hydrograph (Plates 10, 11, and 12, respectively) shows that the plan maintained an adequate channel throughout the reach with each hydrographic condition.

Plan B

Description

During Plan A, it was decided to change the downstream riverside guard wall in the movable-bed model to match the fixed-bed navigation model (Plan E), designated as Plan B. A total of ten runs, the original design and nine modifications of the original, were performed. These examinations were performed so that the bed configurations resulting from this guard wall design could be compared to Plan A and a determination made as to which should be further developed. The structure design as initially installed in the model is shown in Plate 13.

Results

The final run of Plan B (Plate 14) was compared with the runs from Plan A (Plan A-4, Plate 15). Representatives of the New Orleans District; the U. S. Army Engineer Division, Lower Mississippi Valley; the U. S. Army Engineer District, St. Louis (assisted in design of structures and revetments); and the U. S. Army Engineer Waterways Experiment Station conferred and concluded that Plan A should be further developed and no further consideration be given to Plan B. This was based on the superiority of the landside guide wall for navigation and indications from preliminary research that it would be possible to develop Plan A so that sediment deposition in the lower lock approach would be minimized.

Plan C

Description

Following completion of Plan A (Plan B was installed, examined, and rejected before completing operations with Plan A) research, the New Orleans District reformulated and redesigned Locks and Dams 2, 3, 4, and 5. Advances in low-head hydropower technology also allowed the consideration of hydropower units to be constructed as part of the project. Lock and Dam 2 remained in the same location, but was redesigned to go from six to five dam gates, raising the upper pool from el 58 to 64.

The initially installed structures for Plan C (Plate 16) were the non-powerhouse configuration. These operations were performed to examine the potential for shoaling in the lower lock approach with the redesigned dam. Plans C-16 through C-18 examinations had cofferdam cell configurations installed in place of the proposed powerhouse. Two repetitions were run for each plan of the average water year hydrograph to determine if the cofferdam cells would significantly affect sedimentation patterns. Examinations of Plans C-19 through C-24 with the proposed hydropower unit in place concentrated on developing the lower lock approach. Plan C-25 was the same as Plan C-24, except for returning to the cofferdam cell configuration of Plan C-18. Plan C-25 was operated with low, average, and high water year hydrographs. Plan C-26 reinstalled the powerhouse and had a revised plan for the upstream approach to the powerhouse originating from navigation and structures model examinations. After completion of operations with Plan C-26, the model was inactive for approximately 3 years. During this time, authority for the Red River Project was transferred from the New Orleans District to the U. S. Army Engineer District, Vicksburg. The model was reactivated and Plan C-27 was installed. This plan was essentially the same as the plan run with the powerhouse (Plan C-24) with these exceptions: (a) the powerhouse and cofferdam cells were removed and (b) the right bank revetment was put back to the nonpowerhouse design. After this plan, the powerhouse was reinstalled in the Plan C-26 configuration. Work was focused on eliminating any shoaling tendencies in the lower lock and upper powerhouse approaches. Modifications were made from Plan C-28 through C-49 to reduce or eliminate these shoaling tendencies. Almost all the examinations were performed by introducing a colored plastic material (with approximately the same specific gravity as the coal) and dye into the model, then monitoring the movement of the plastic material and dye. If any tendency was shown for either to go into the lower lock approach, the model was stopped and a new plan installed. No bed surveys were taken during these runs. The Vicksburg District requested that operation with the powerhouse design be stopped and efforts concentrated on developing the nonhydropower design so that the lower lock approach would have little or no tendencies for shoaling. Since no model bed surveys were made during most of these operations and research was incomplete at the time that work was suspended, results of operation for Plans C-27 through C-49 will not be discussed.

Plan C-50 was the first plan examined with the nonpowerhouse configuration to reduce shoaling in the lock approaches. Modifications to this plan were made through Plan C-114. Plan C-81 developed and maintained the channel better than any plan up to that time and received extensive evaluation, but these examinations indicated that problems would develop; therefore, continued examination of and modifications to the plan were made. After completion of Plan C-114, the Vicksburg District requested that the configuration of Plan C-81, the most successful plan developed, be installed in the model and examined to improve sedimentation conditions in the upper lock approach. The first modification was to install ten submerged dikes along the left bank, upstream of the lock approach to el 49. Various changes were made including the following: adding and removing submerged dikes, adding a fixed berm just upstream of the lock

approach, removing and modifying the right bank spur dikes, and modifying the right bank revetment alignment. Twelve modifications were made to Plan C-81 (C-81, Modification 12). Most modifications made to Plan C-81 were run through at least three consecutive hydrographs before the model was surveyed. After examination of Modification 12, the Vicksburg District requested that the as-built prototype configuration be reinstalled in the model and examined from the time the pool is established until the deposition in the pool reaches stability. The time of pool establishment was referred to as T-zero. A total of 18 repetitions of the average hydrograph were performed. Prior to Run 19, the two right bank dikes and the right bank revetment near the confluence were modified to reflect the as-built design. An additional 12 repetitions of the typical hydrograph, for a total of 30, were performed. Five repetitions of the 1982-1983 hydrograph (Plate 17) were then performed. After this, the lower navigation channel was dredged to design specifications and three additional repetitions of the 1982-1983 hydrograph were reproduced, then one repetition of the 1958 high water year hydrograph. An additional run was made with the 1982-1983 hydrograph; then, the elevation of the first five dikes along the right bank downstream of the dam were raised and the channel dredged from the lower lock approach downstream approximately one mile. Two repetitions of the 1982-1983 hydrograph were then performed.

Results, Plans C through C-15

The model survey taken after five repetitions of the average water year hydrograph with the newly reconfigured dam (Plate 18) shows that the upper pool was gradually filling. A scour hole had developed in the upstream lock approach opposite the upstream end of the guard wall, and there was a large scour upstream of the dam upstream to the end of the guard wall. Below the dam, the lower lock approach had a large shoal along the guide wall. An adequate channel was maintained from the end of the guide wall to the downstream end of the model. The final examination performed in the prepowerhouse configuration, Plan C-15 (Plate 19), shows the upper pool still filling. The modified dikes along the right bank eliminated the scour in the upper lock approach, and reduced the scour upstream of the dam somewhat. The trailing dike off the downstream right side of the dam reduced the shoaling in the lock approach, but did not eliminate it. There was some shoaling along the channel ends of the dikes downstream of the confluence, but an adequate navigation channel continued to exist.

Results, Plans C-16 through C-18

Comparing the final run of each cofferdam cell plan examined, Plans C-16 through C-18, with the final run without the cofferdam cells, Plan C-15 (Plates 20-22 versus Plate 19), Plan C-16 (Plate 20) has some additional shoaling downstream of the trailing dike off the end of the lock. Plan C-17 (Plate 21) has

additional shoaling along the channel side of the trailing dike. Plan C-18 (Plate 22) completely eliminated the shoaling along the channel side of the trailing dike. All cofferdam plans examined did not change the tendency for shoaling along the left bank in the lower lock approach.

Results, Plans C-19 through C-26

Plan C-19 results show that bed material would shoal just below the downstream guide wall in the lock approach (Plate 23). Plan C-24 results show that modifications had eliminated shoaling in the lower lock approach (Plate 24). The survey of Plan C-25, after four repetitions of the average water year hydrograph (Plate 25), showed that the structures in place for Plan C-24 would prevent shoaling in the lower lock approach during construction phases of the powerhouse. The survey taken after the 1958 high water year hydrograph showed shoaling along the channel side and off the downstream end of the trailing dike off the downstream end of the lock (Plate 26). The channel downstream of the lock approach shoaled considerably compared with the average water year hydrograph survey. The survey taken after the 1971 low water year hydrograph (Plate 27) showed that shoaling along the channel side and off the downstream end of the trailing dike increased over that of the high water year hydrograph (Plate 26). The channel completely shoaled in the area with the confluence of the downstream old channel. It should be noted that the low water year hydrograph was performed immediately following the high water year hydrograph without any dredging between the runs. Examination of Plan C-26, which was the same as Plan C-24 except that Plan C-26 used the new entrance channel design for the powerhouse, showed that with the average, high, and low water hydrographs (Plates 28, 29, and 30, respectively) there was no bed material accumulation within the lower lock approach. However, at the end of the high and low water hydrographs, the navigation channel was constricted from a shoal along the right bank in the area of the downstream confluence with the old channel.

Results, Plans C-50 through C-114

The final run made with Plan C-50 (Plate 31) showed bed material shoaled along the downstream end of the guide wall and the channel completely shoaled just below the confluence. Many modifications were made to this plan and examined. The final plan examined, Plan C-114 (Plate 32), showed that there was some shoaling along the channel side of the large trailing dike of the downstream end of the lock and the channel shoaled completely just below the confluence.

Results, Plan C-81

During examination of Plans C-50 through C-114, the plan developed for C-81 showed the most promise. This plan was examined extensively with the average,

high, and low water year hydrographs. The major features of this plan were as follows:

a. Three spur dikes along the right bank, the most upstream dike angled downstream 45 degrees to the flow, the other two angled at 15 degrees to the flow, with crest lengths of 30, 90, and 170 ft, respectively, starting 6,550 ft upstream of the dam, spaced 600 ft between the first and second dike and 500 ft between the second and third dikes, all to el 75.

b. A berm along the left bank in the upstream lock approach to el 48, beginning 1,700 ft upstream of the dam.

c. Three spur dikes along the right bank angled upstream, the most upstream dike at approximately 45 degrees and the two most downstream dikes at approximately 30 degrees, beginning at 800 ft downstream of t the dam, spaced approximately 375 ft apart, with crest lengths of 300, 250, and 250 ft, respectively, and all at el 41 at the channel end and el 48 at the bank.

d. A trailing dike off the riverward side of the lock downstream of the dam with the section that joined the lock being angled about 5 degrees riverward of the axis of the center line of the lock, extending 289 ft downstream from the end of the lock at el 74.5, then turning at a 45-degree angle toward the river relative to the center line of the lock, extending 30 ft and sloping from el 74.5 to 50.0, then turning to parallel the center line of the lock, extending an additional 400 ft at el 50.

e. Three left bank spur dikes perpendicular to the center line of the lock, the first being 1,615 ft downstream of the dam, spaced 200 ft apart, with crest lengths of 155 ft and all to el 70.

The contraction works system used for Plan C-81 (Plate 33) was developed to reduce any tendencies for sediment to deposit in the downstream lock approach. The trailing dike off the downstream end of the lock was designed so that flow could not pass over the dike until approximately 300 ft downstream of the lower end of the lock, preventing any tendency to shoal in the entrance to the lock. The 400-ft section of the dike that was parallel with the lock at el 50 was designed to allow flow to overtop the dike during high tailwater events. During events with the tailwater elevation less than 50, no flow passed over the dike. During higher stages, flow passed over the dike and "flushed" the downstream lock approach along the length of the trailing dike, reducing the tendency for deposition in the lower lock approach. This removed any sediment that had deposited after passing the downstream end of the trailing dike in the slack-water area that existed during low tailwater elevations immediately downstream of the trailing dike. The long trailing dike prevented the sediment from moving into the downstream lock approach and directed the sediment that passed through the dam into the 300-ft-width channel 2,000 ft downstream of the dam. Three spur dikes, the most

upstream dike angled upstream at approximately 45 degrees and the two most downstream dikes at approximately 30 degrees to the direction of flow, with el of 48 at the bank and 41at the channel end, were designed to align the water flow and sediment away from the right bank. The three spur dikes on the left descending bank at el 70 were designed to constrict the width of the channel during a high tailwater event. This was required to prevent deposition of material along the left bank near the downstream end of the trailing dike.

Results, Plan C-81, Modifications 1 through 12

The survey taken after completion of Plan C-81, Modification 1 (Plate 34) showed considerable filling between the submerged dikes in the upstream lock approach. The three submerged dikes closest to the lock were almost completely covered, and bed material entered the upstream lock approach opposite the guard wall. Shoaling off the upstream end of the guard wall was within a few feet of minimum navigation depth at the normal pool elevation. The final modification made, Plan C-81, Modification 12 (Plate 35), showed the berm installed just upstream of the ported guard wall was an improvement in reducing the tendency for shoaling along the left bank and inside the lock approach. There was still a tendency for material to accumulate off the downstream end of the berm, but there was no material within the lock approach opposite the guard wall.

Results, Plan C-81, T - 0 runs

Comparing the surveys taken after completion of the first hydrograph (Plate 36) and after completion of the eighteenth hydrograph (Plate 37) showed that the entire riverbed was slowly aggrading. A large portion of the navigation channel was maintained downstream of the confluence, but was slightly narrower due to shoaling along the ends of the dikes. Shoaling in the upper pool appeared somewhat worse than below the dam. Comparing the survey after the eighteenth run with that after the thirtieth run (Plates 37 and 38), it is apparent that the upper pool was still aggrading. The channel through the dike field downstream of the downstream confluence almost completely filled above navigation depth. This is likely due to an increase in sediment passing from the upper pool through the dam, as the upper pool approached an equilibrium of material coming into the pool and material passing through the dam.

When the survey taken after the fifth repetition of the 1982-1983 hydrograph (Plate 39) is compared with the final run with the typical hydrograph (Plate 38), only minor differences appear. The survey taken after one hydrograph after dredging the lower channel (Plate 40) showed the channel downstream of the lower lock approach filled quickly, especially the last mile of the modeled reach. The survey taken after two additional repetitions of the 1982-1983 hydrograph (Plate 41) showed some additional shoaling in the channel downstream of the dam, but no major differences compared with the first hydrograph after dredging (Plate 40). The survey taken after completion of the 1958 hydrograph (Plate 42)

showed no major differences compared with the previous survey taken after operation with the 1982-1983 hydrograph (Plate 41). The next run made with the 1982-1983 hydrograph (Plate 43) showed little difference compared with the survey taken after the 1958 hydrograph (Plate 42). The final run, made after changing the elevations of the right bank dikes downstream of the dam and dredging the channel downstream of the dam (Plate 44), showed the channel was slightly worse just downstream of the confluence and slightly better for the last mile of the model reach compared with the first run made after dredging the channel below the dam (Plate 40).

Plan D

Description

Plan D was performed to examine channel repair options of the downstream lock approach after an extreme flow event caused significant damage in the downstream approach channel in the prototype. Plan D was the same as Plan C-81, Modification 12, except that the left bank line was realigned to reduce the scour occurring off the end of the trail dike that extends from the right downstream lock wall. Plan D-1 removed the most downstream reverse angle dike below the dam on the right bank line and realigned the right bank line at the confluence to increase the channel width at el 26 to 350 ft. The 1982-1983 hydrograph was used for all runs with Plan D. Plan D as installed in the model is shown in Plate 45.

Results

The survey taken after Plan D, Run 1 (Plate 46), indicated some overall scour reduction off the end of the trail dike, except near the end of the right bank riprap at sta 24+00. It was noted that the tailwater rating curve used at that time in the model was developed prior to construction of Lock and Dam 2 and was considerably different from the actual prototype rating curve developed from recent prototype data. It was believed the model was underestimating the scour that would occur due to this difference.

The Vicksburg District requested that Plan D be examined again, this time removing the most downstream reverse angle dike below the dam and realigning the right bank revetment near the confluence, designated Plan D-1. The results of this examination (Plate 47) indicated a substantial decrease in scour off the end of the trail dike but an increase in deposition along the left bank line below the lock entrance and adjacent to the scour, up to el 41.

Plan E

Description

The Vicksburg District proposed building two submerged dikes upstream of the berm in the upper lock approach to reduce deposition occurring along the left bank in the upper lock approach. This was done to evaluate options to reduce or eliminate deposition and flow condition problems in the upper lock approach of the prototype. The Vicksburg District proposed building the dikes on the deposition that existed at that time to reduce the volume of rock required and requested that model research determine the effectiveness of the dikes and the possible benefits of removing a portion of the berm in the upstream lock approach, then replacing this berm with dikes. Before research was begun, the model was reverified to reflect the as-built condition of the upper pool. The model bed was molded to the February 1989 prototype configuration (Plate 48). The model was reverified using the 1989 hydrograph (Plate 49) and the February (Plate 48) and September 1989 (Plate 50) hydrographic surveys. Two Base Examination runs were performed with the average water year hydrograph and one run was performed with the 1989 hydrograph. The two proposed submerged dikes were first installed and examined through three repetitions of the typical water year hydrograph. Three additional submerged dikes were installed after the berm upstream of the lock approach and the dikes along the right descending bank were removed, and the right descending bank of the natural channel was connected to the right descending bank of the excavated channel by constructing a bank line to el 70. This modification was designated as Plan E-1.

Results

The model readjustment survey (Plate 51) compares favorably with the prototype survey of September 1989 (Plate 50). The Base Examination survey taken after two repetitions of the average water year hydrograph (Plate 52) shows a strong tendency for shoaling along the left bank upstream of the berm. The survey taken after the 1989 highwater year hydrograph (Plate 53) shows that some of the material deposited along the left bank during the average water years had scoured away.

The survey taken of Plan E after three repetitions of the average water year hydrograph (Plate 54) indicated that deposition along the left descending bank line was reduced compared with the Base Examination condition after two repetitions of the same hydrograph (Plate 52). The survey taken after the fourth repetition of the average year hydrograph with Plan E-1 (Plate 55) indicated that deposition along the left bank would be as great as, if not greater than, the Base Examination condition without any submerged dikes (Plate 52).

4 Conclusions

Model Limitations

The limitations of this model are based on the presumption that the major portion of sediment being deposited in this system is bed load. The Red River has a heavy concentration of fine material that remains suspended within the water column when current velocities remain high enough. In areas of slack or very slowly moving water, this material tends to drop out.

The movable-bed model used for this study is designed to look specifically at bed load material. The model was not and could not be used to address the problems associated with suspended load and how it might affect the design of the structures and channel contraction works. Even with this limitation, the model study was considered to be adequate to successfully evaluate the proposed lock and dam design and to develop contraction works to minimize deposition within the navigation channel.

Model Conclusions

The following conclusions were reached from the results of the model study:

a. Plan A-23 as developed with the original six-gate, 58-ft pool dam design adequately maintained the navigation channel throughout the study reach.

b. Plan B, using a downstream guard wall, was unacceptable due to the superiority of the downstream guide wall (as used in Plan A) for navigation purposes.

c. Plans C through C-15 indicated filling of the upper lock approach and shoaling along the left bank in the lower lock approach.

d. Plan C-18 (cofferdam plan) eliminated shoaling near the lower lock approach.

e. Plan C-26 (hydropower plan) eliminated shoaling in the lower lock approach.

f. Plans C-50 through C-114 (without cofferdam or powerhouse) did not completely prevent shoaling in the lower lock approach and near the lower confluence.

g. Plan C-81, Modification 12 (best plan for lower lock approach from examination of Plans C-50 through C-114), reduced the tendency for deposition along the left bank of the upper lock approach.

h. Plan C-81, T-0, runs 1 through 30, indicated that the channel through the dike field downstream of the lower confluence will gradually shoal over time.

I. Plan D reduced the scour off the downstream end of the trailing dike extending from the lock. Plan D-1 reduced the scour, but increased deposition along the left bank in the lower lock approach.

j. Plan E prevented shoaling in the upper lock approach, but Plan E-1 would likely increase shoaling as compared with the Base Examination conditions.

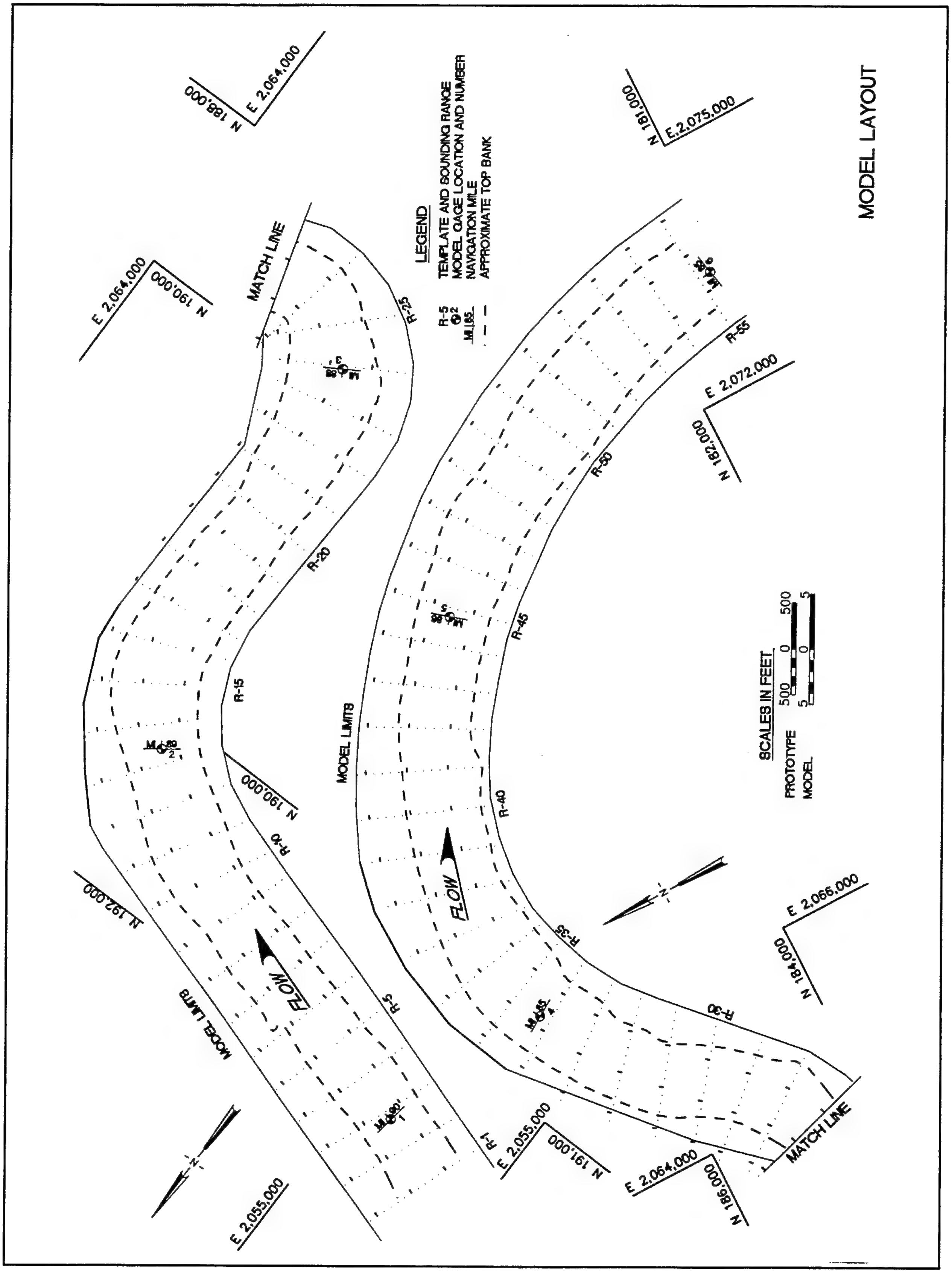

MODEL LAYOUT
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
⊕2 MODEL GAGE LOCATION AND NUMBER
MI 185 NAVIGATION MILE
APPROXIMATE TOP BANK
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
FLOW
FLOW
MATCH LINE
MATCH LINE
MODEL LIMITS
MODEL LIMITS
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
N 188,000
E 2,064,000
N 190,000
E 2,064,000
N 190,000
N 192,000
E 2,055,000
E 2,055,000
N 191,000
E 2,064,000
N 186,000
E 2,066,000
N 184,000
E 2,072,000
N 182,000
N 181,000
E 2,075,000

Plate 1

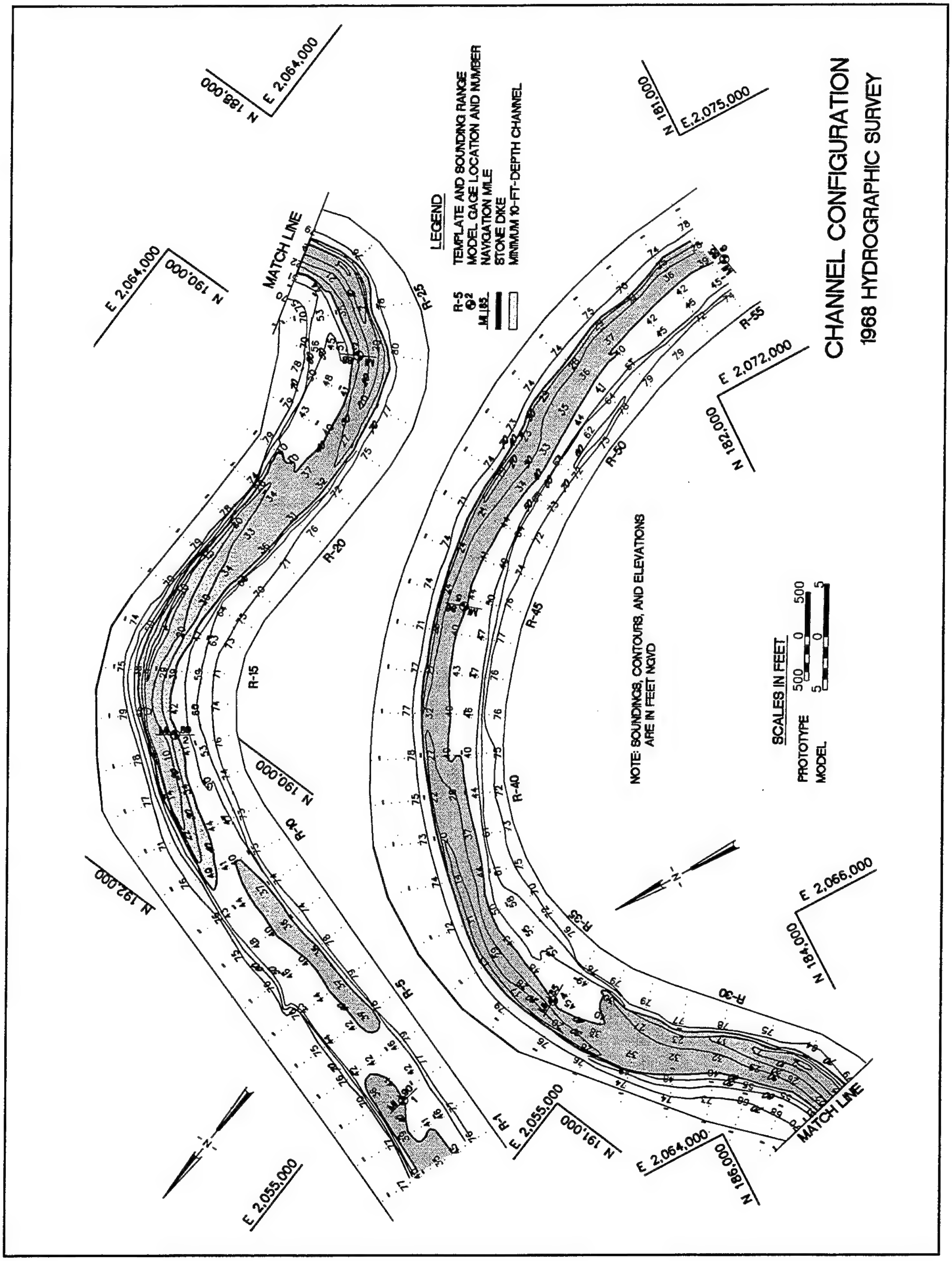
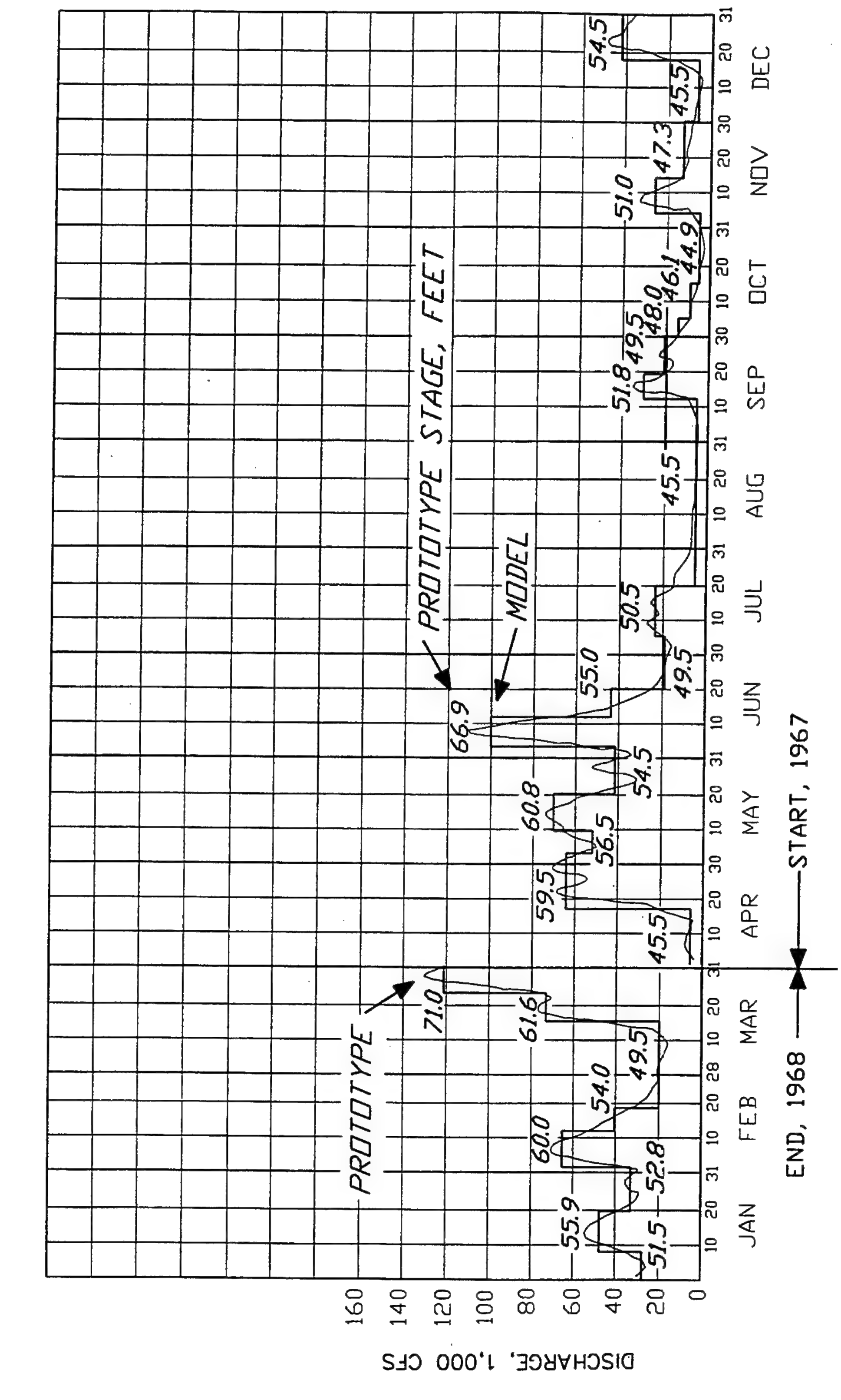

CHANNEL CONFIGURATION
1968 HYDROGRAPHIC SURVEY
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
⊕2 MODEL GAGE LOCATION AND NUMBER
M.185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
N 188,000
E 2,064,000
N 190,000
E 2,064,000
N 181,000
E 2,075,000
E 2,072,000
N 182,000
N 190,000
N 192,000
E 2,066,000
N 184,000
E 2,055,000
N 191,000
E 2,064,000
N 186,000
E 2,055,000
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55

Plate 2



1967-1968 HYDROGRAPH

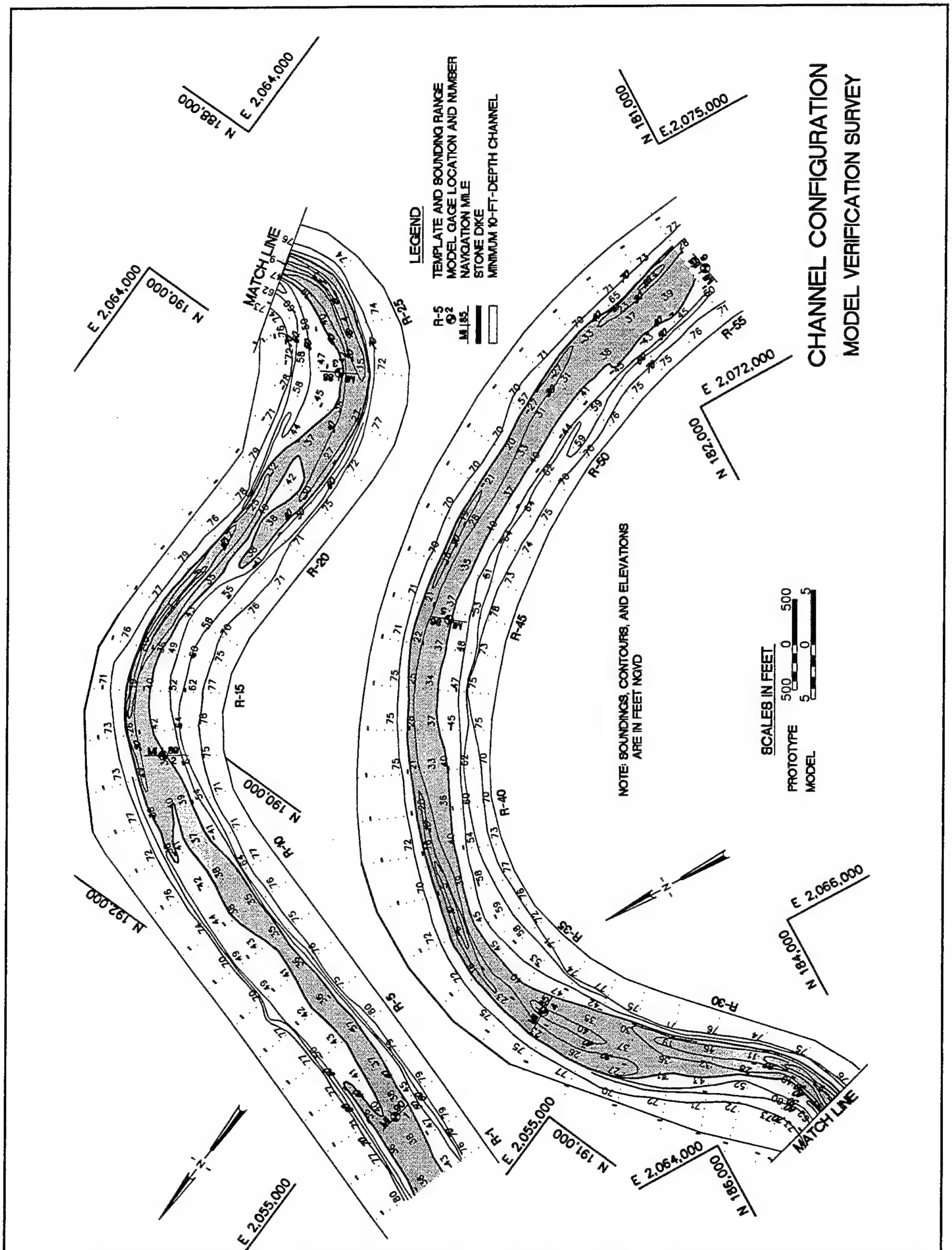
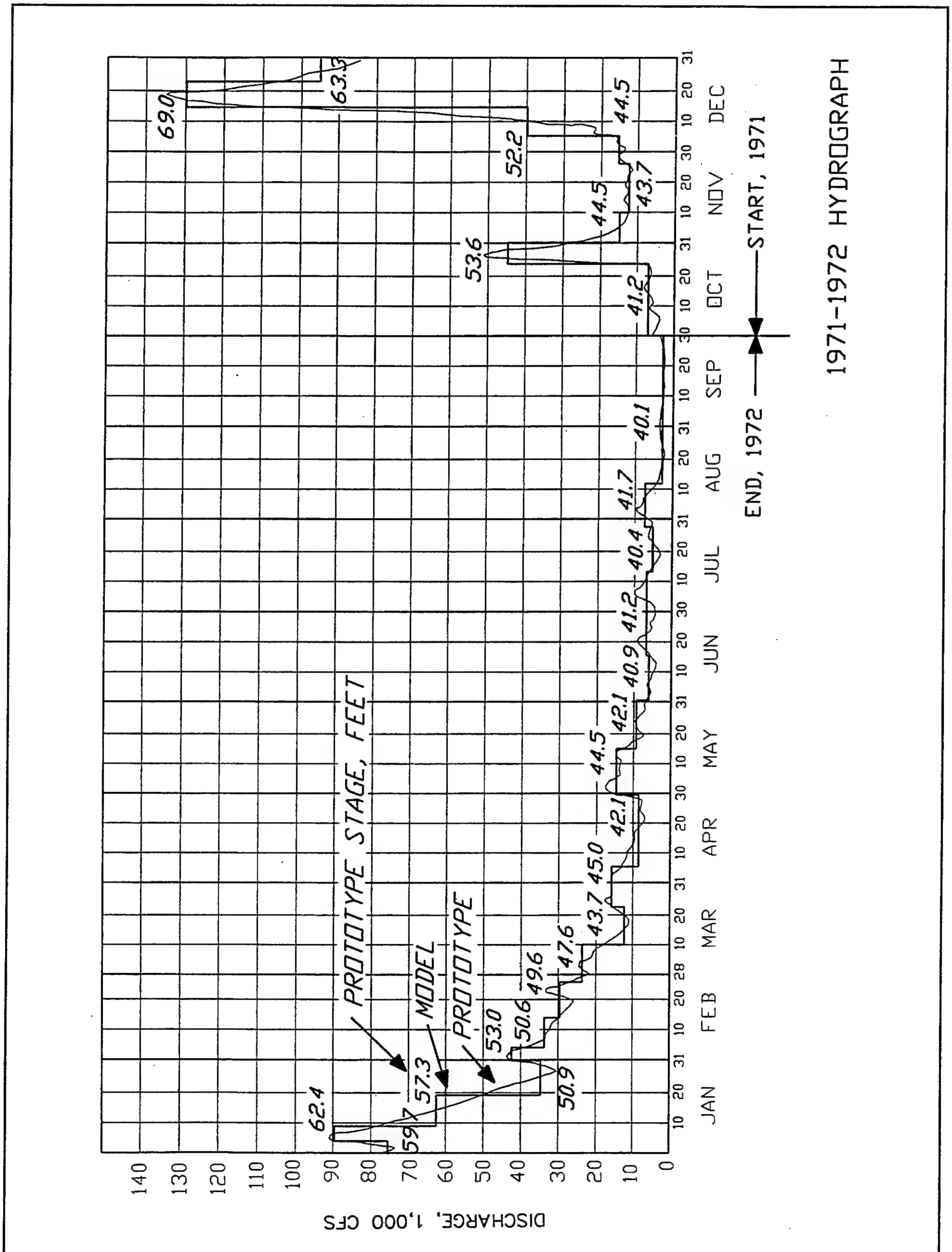

CHANNEL CONFIGURATION
MODEL VERIFICATION SURVEY
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
M 185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
N 188,000
E 2,064,000
N 190,000
E 2,064,000
N 181,000
E 2,075,000
E 2,072,000
N 182,000
N 190,000
N 192,000
E 2,066,000
N 184,000
E 2,055,000
N 191,000
E 2,064,000
N 186,000
E 2,055,000
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55

Plate 4


1971-1972 HYDROGRAPH
DISCHARGE, 1,000 CFS
PROTOTYPE STAGE, FEET
MODEL
PROTOTYPE
END, 1972
START, 1971
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

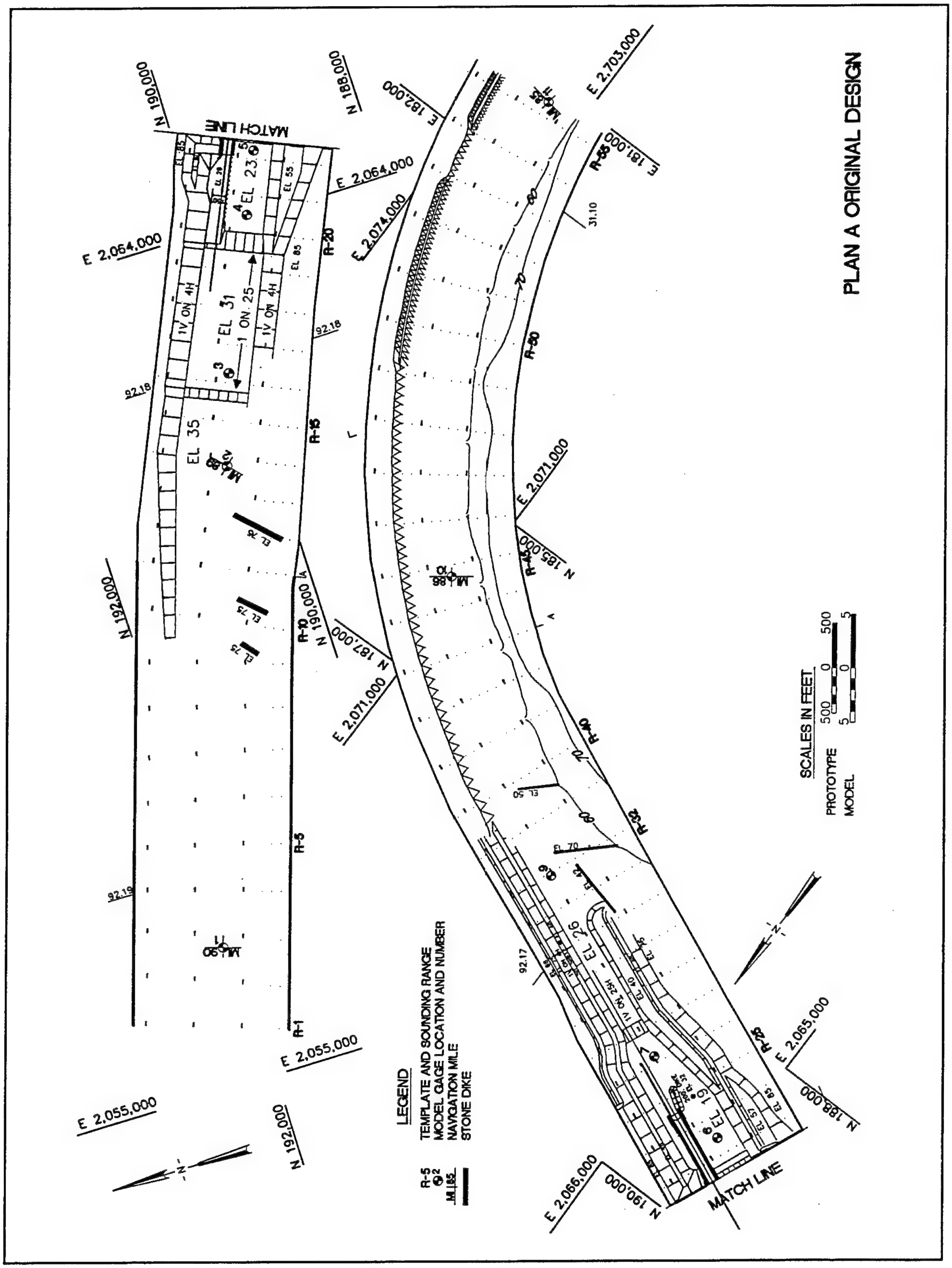
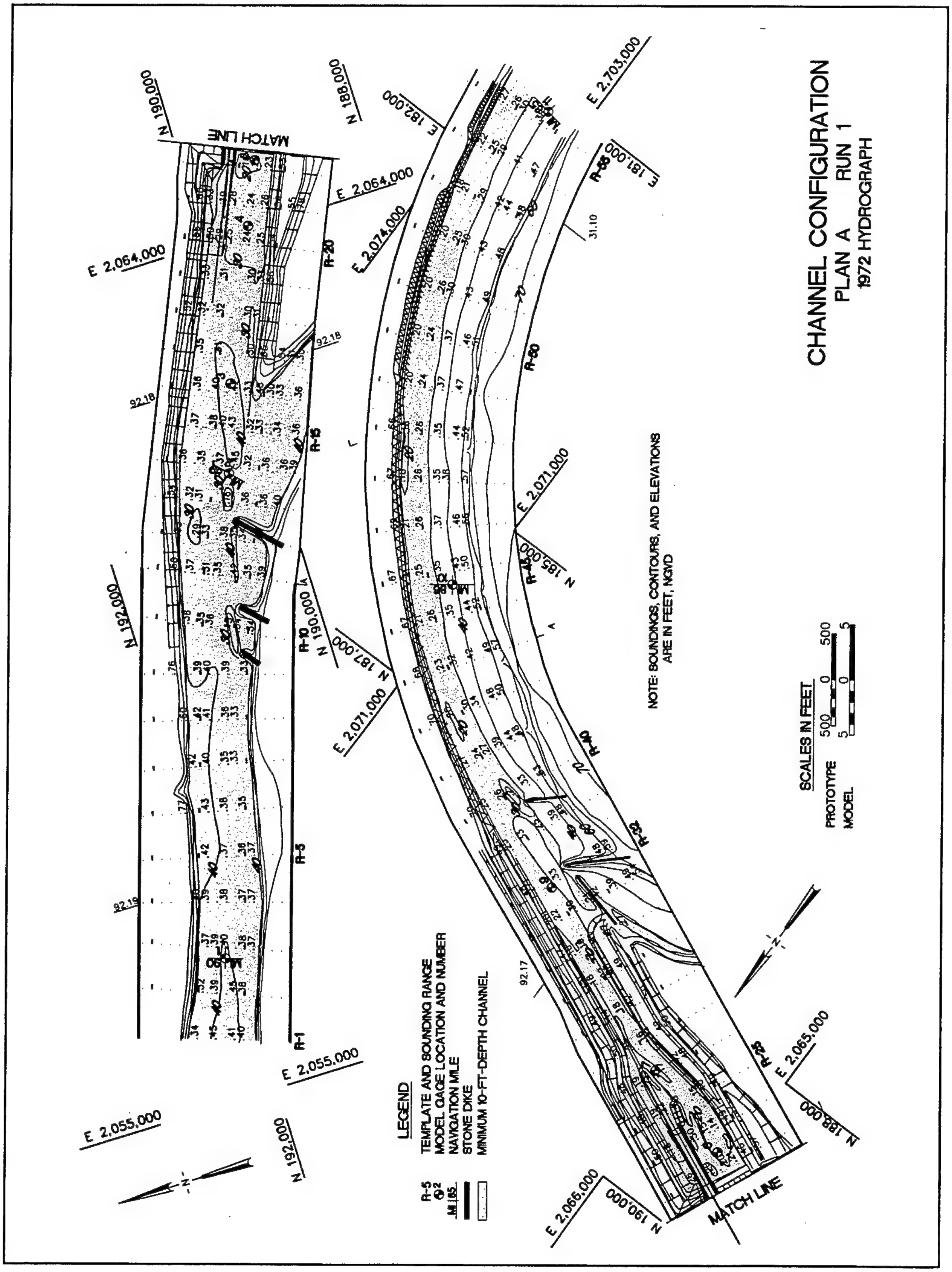

PLAN A ORIGINAL DESIGN
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
2 MODEL GAGE LOCATION AND NUMBER
M 185 NAVIGATION MILE
STONE DIKE
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
N 192,000
N 192,000
E 2,064,000
E 2,064,000
N 190,000
N 188,000
E 2,074,000
E 182,000
E 2,703,000
E 181,000
E 2,071,000
E 2,071,000
N 185,000
N 187,000
N 190,000
E 2,065,000
N 188,000
E 2,066,000
N 190,000
EL 35
EL 31
EL 23
EL 26
EL 19
1 ON 25
1V ON 4H
1V ON 4H
EL 70
EL 50
R-1
R-5
R-10
R-15
R-20
R-25
R-32
R-40
R-45
R-50
R-55
92.19
92.18
92.18
92.17
31.10

Plate 6


CHANNEL CONFIGURATION
PLAN A RUN 1
1972 HYDROGRAPH
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
M 185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET, NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
N 190,000
N 188,000
N 192,000
N 192,000
N 190,000
N 187,000
N 185,000
N 182,000
N 181,000
N 188,000
N 190,000
E 2,064,000
E 2,064,000
E 2,055,000
E 2,055,000
E 2,074,000
E 2,071,000
E 2,071,000
E 2,073,000
E 2,065,000
E 2,066,000
R-1
R-5
R-10
R-15
R-20
R-25
R-32
R-40
R-45
R-50
R-55

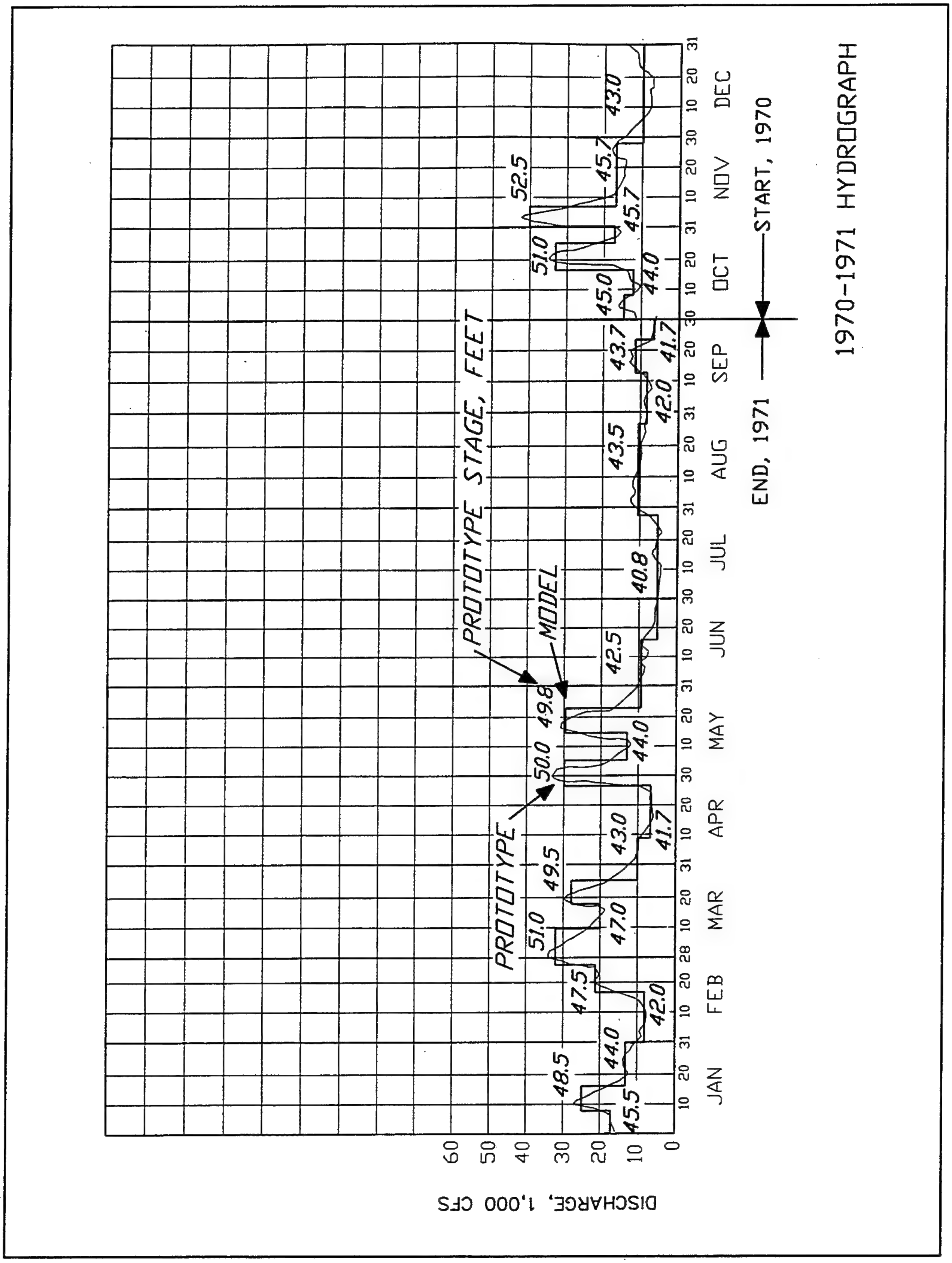
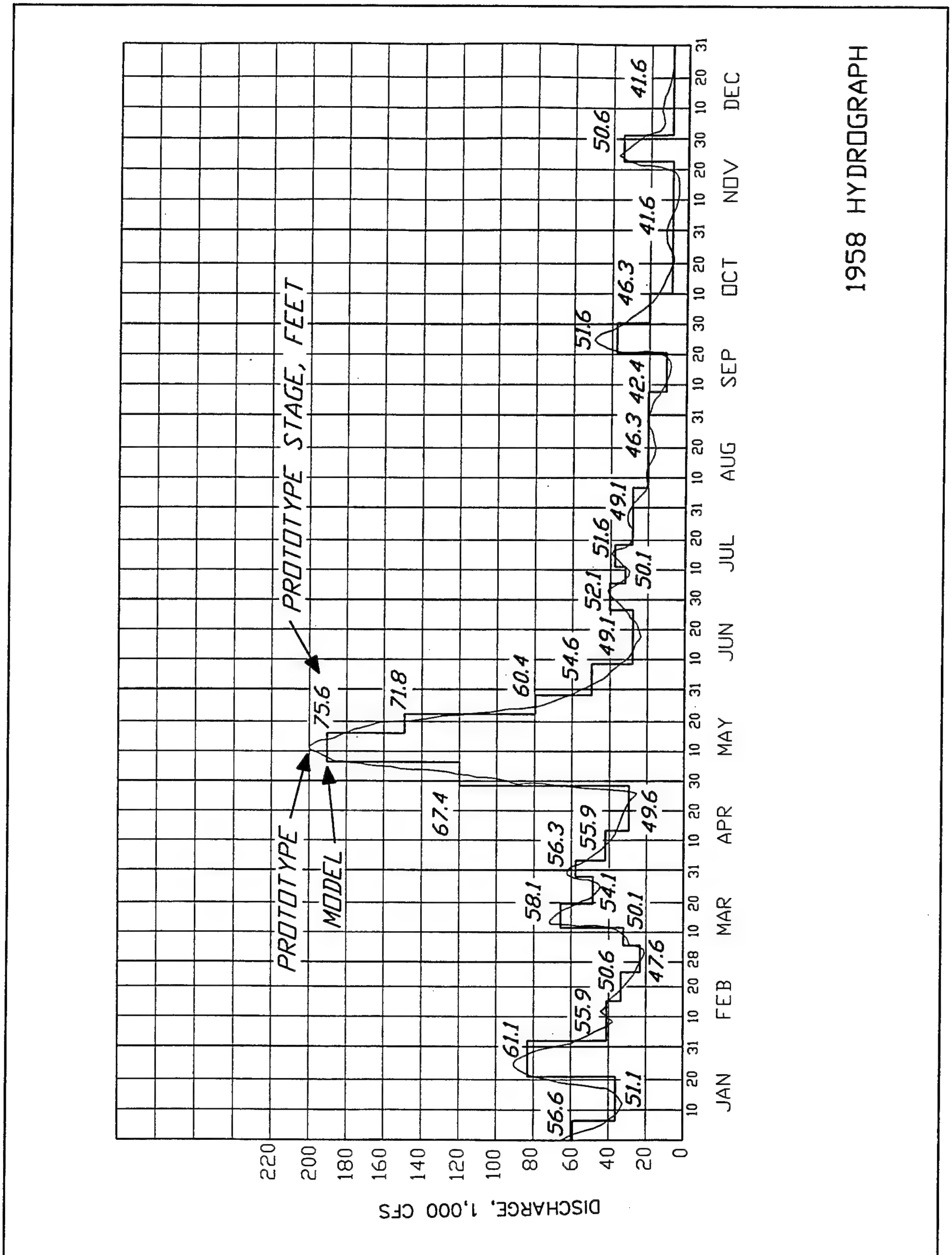

1970-1971 HYDROGRAPH
DISCHARGE, 1,000 CFS
PROTOTYPE STAGE, FEET
PROTOTYPE
MODEL
END, 1971
START, 1970
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 10 20 30 40 50 60
45.5
48.5
44.0
42.0
47.5
51.0
47.0
49.5
43.0
41.7
50.0
44.0
49.8
42.5
40.8
43.5
42.0
43.7
41.7
45.0
44.0
51.0
45.7
52.5
45.7
43.0

Plate 8



1958 HYDROGRAPH
DISCHARGE, 1,000 CFS
0
20
40
60
80
100
120
140
160
180
200
220
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
PROTOTYPE
MODEL
PROTOTYPE STAGE, FEET
56.6
51.1
61.1
55.9
50.6
47.6
50.1
58.1
54.1
56.3
55.9
49.6
67.4
75.6
71.8
60.4
54.6
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51.6
49.1
46.3
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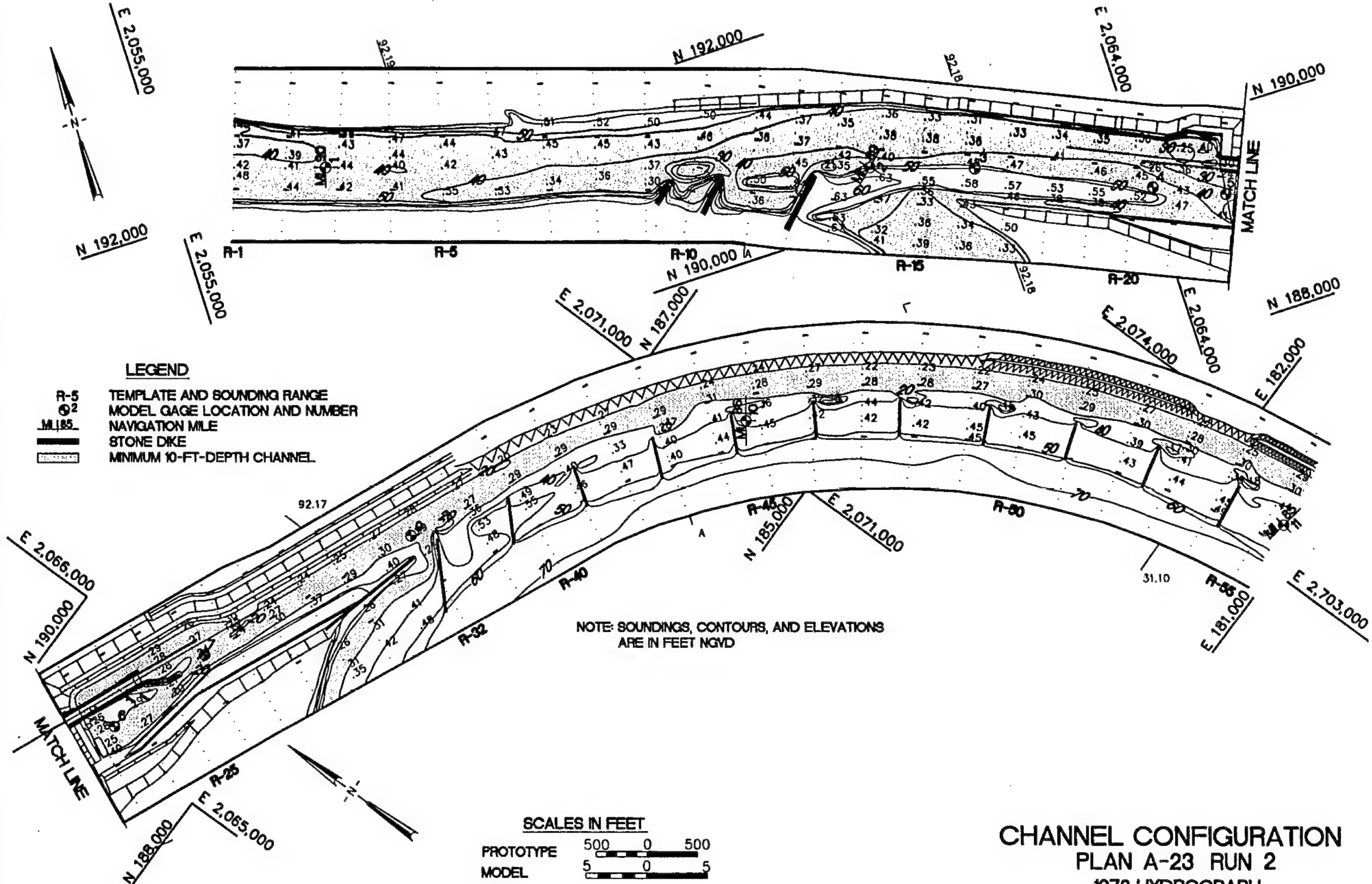
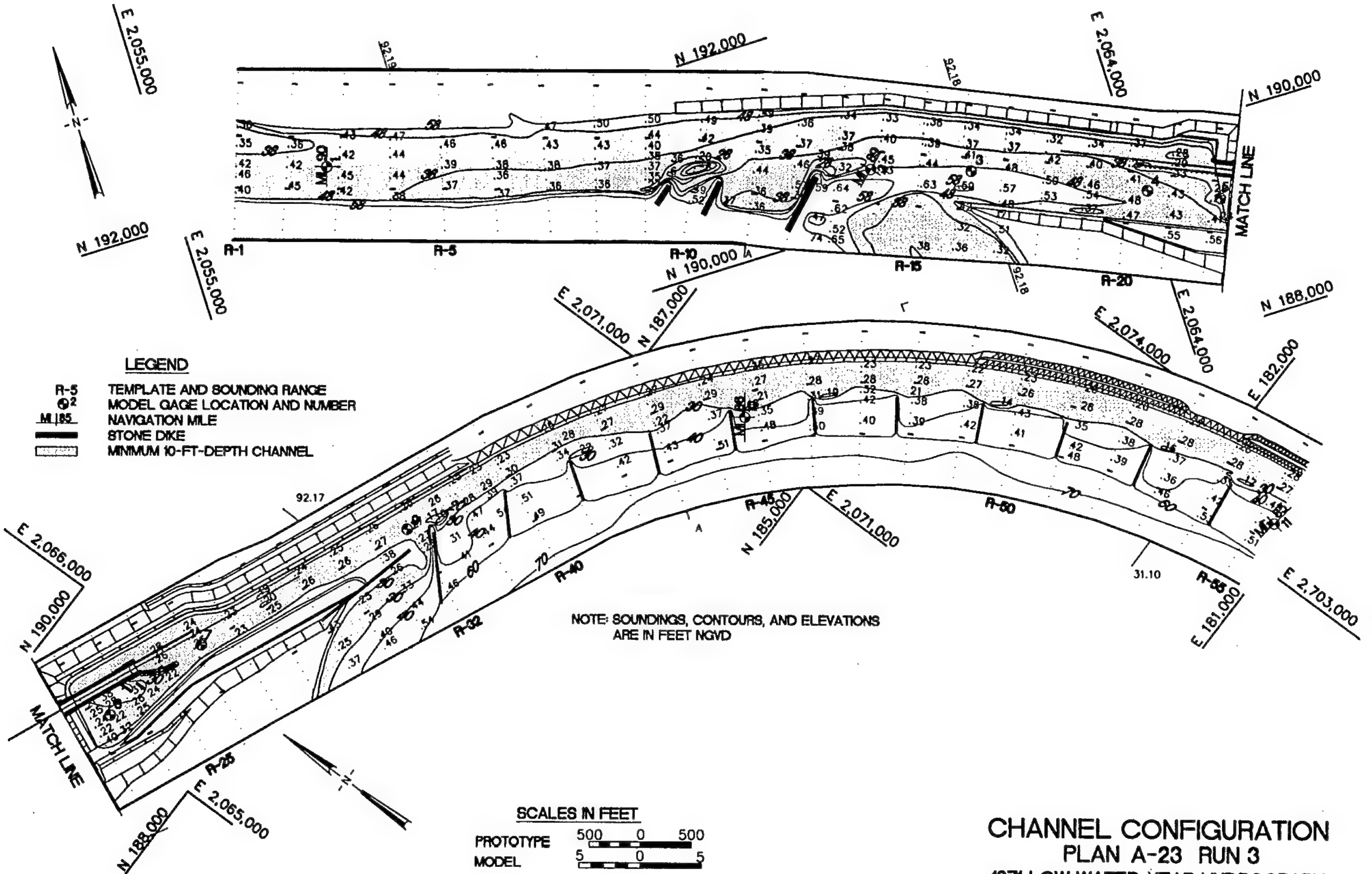
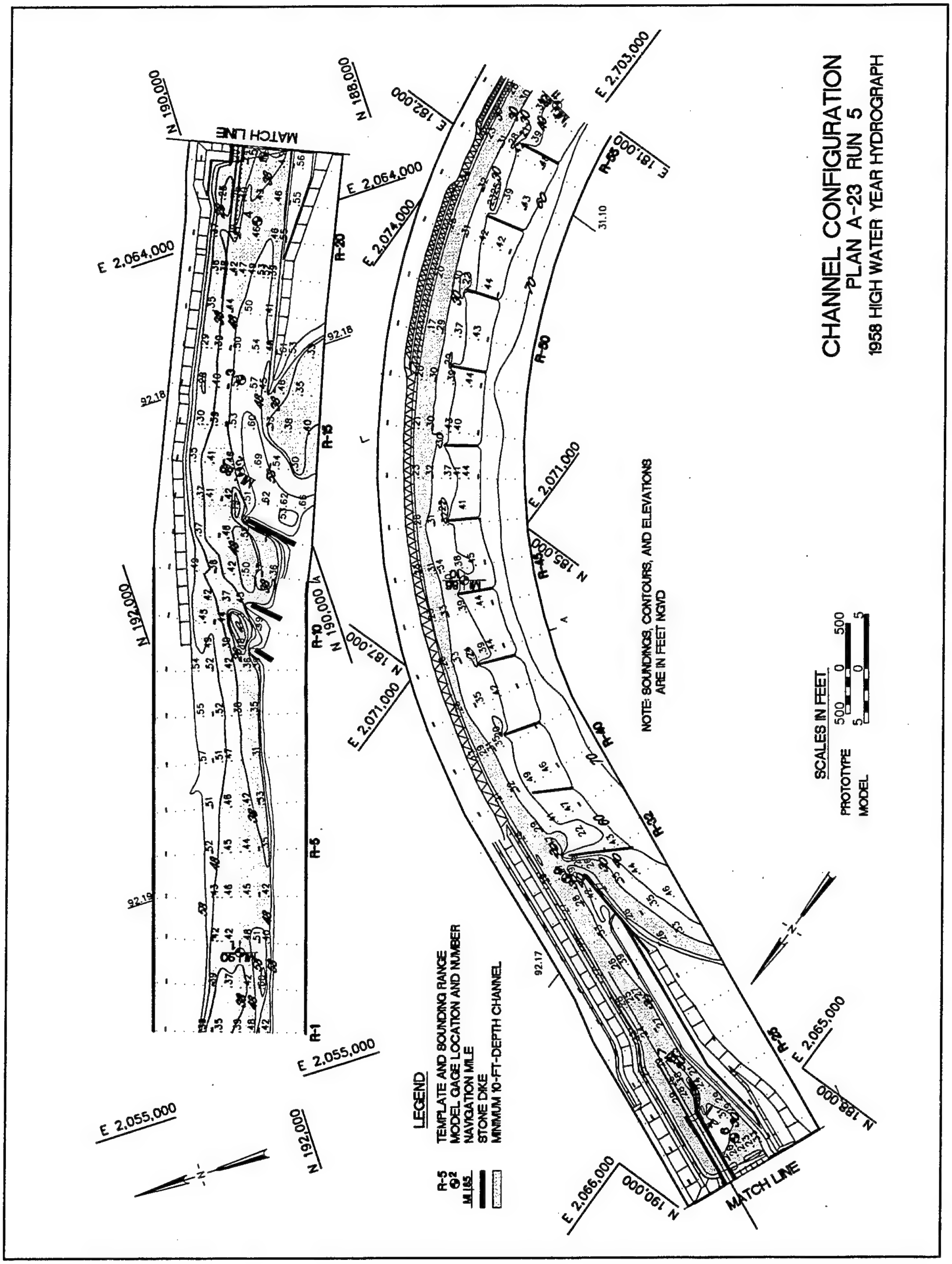
41.6
50.6
41.6

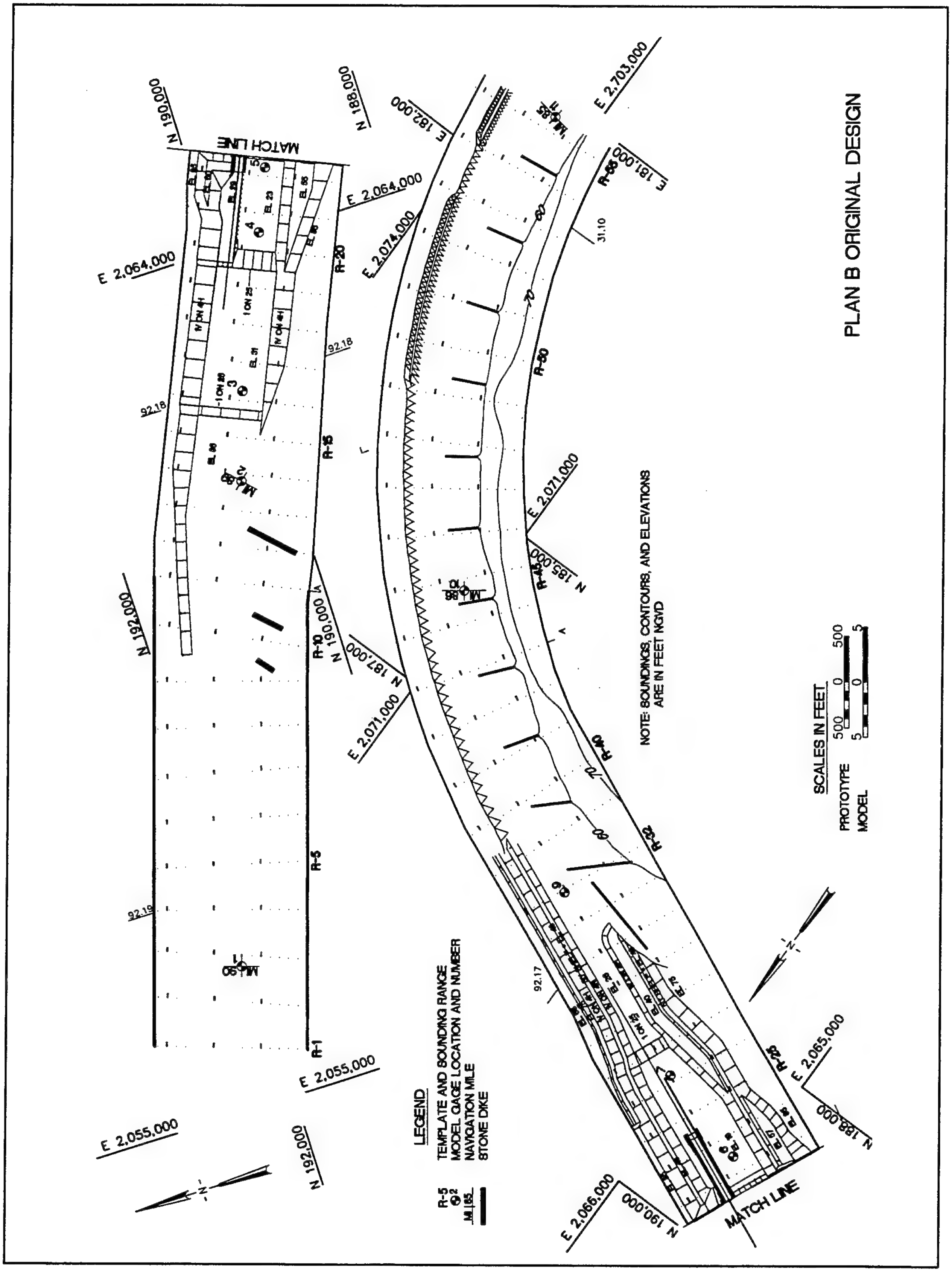


CHANNEL CONFIGURATION
PLAN A-23 RUN 2
1972 HYDROGRAPH



CHANNEL CONFIGURATION
PLAN A-23 RUN 3
1971 LOW WATER YEAR HYDROGRAPH


CHANNEL CONFIGURATION
PLAN A-23 RUN 5
1958 HIGH WATER YEAR HYDROGRAPH
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,064,000
E 2,055,000
E 2,071,000
E 2,074,000
E 2,703,000
E 2,065,000
E 2,066,000
N 190,000
N 192,000
N 188,000
N 187,000
N 185,000
N 182,000
N 181,000
R-1
R-5
R-10
R-15
R-20
R-30
R-35
R-40
R-45
R-50
R-55



PLAN B ORIGINAL DESIGN
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
2 MODEL GAGE LOCATION AND NUMBER
MI 85 NAVIGATION MILE
STONE DIKE
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,064,000
E 2,071,000
E 2,074,000
E 2,066,000
E 2,065,000
E 2,703,000
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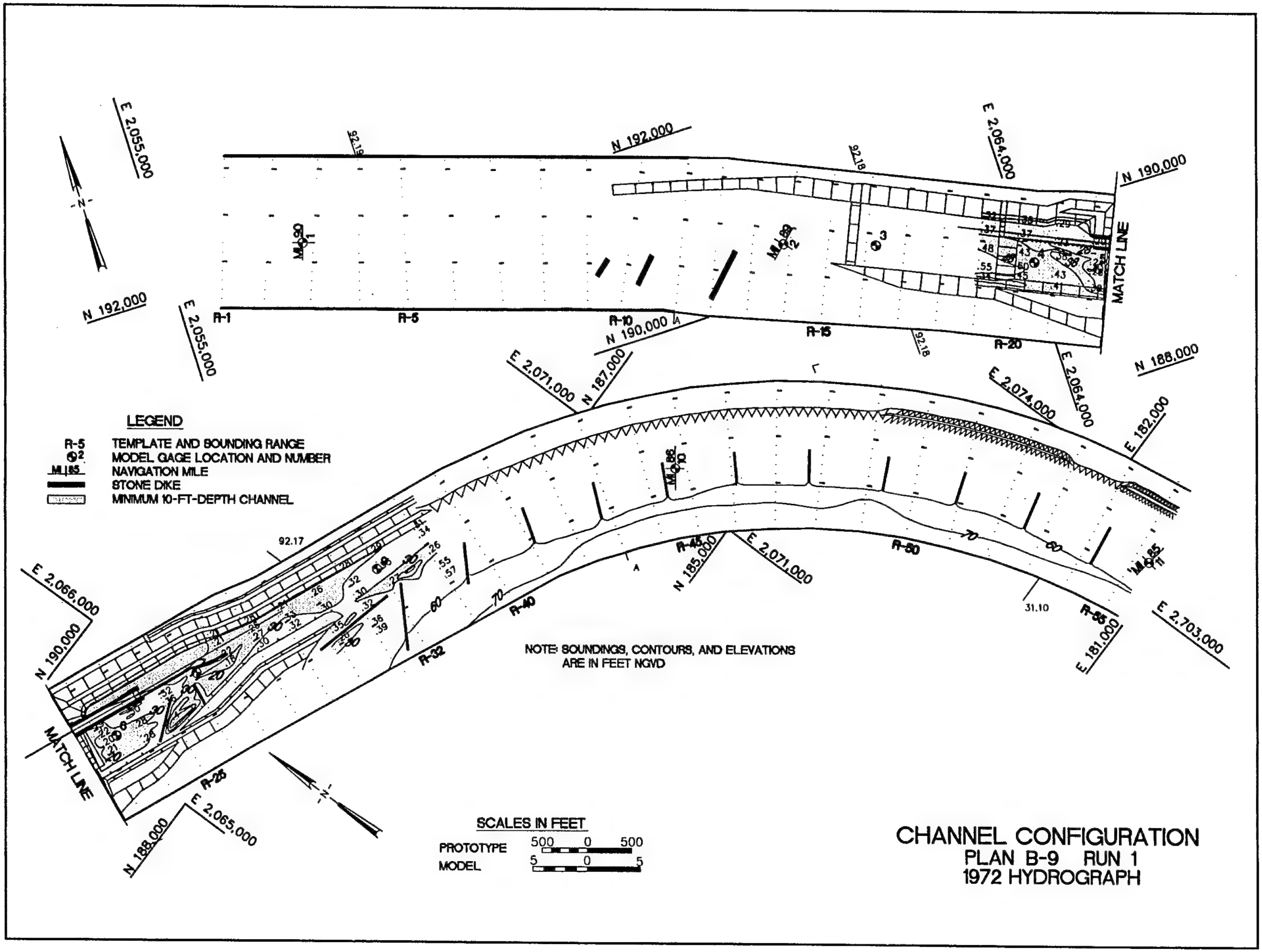
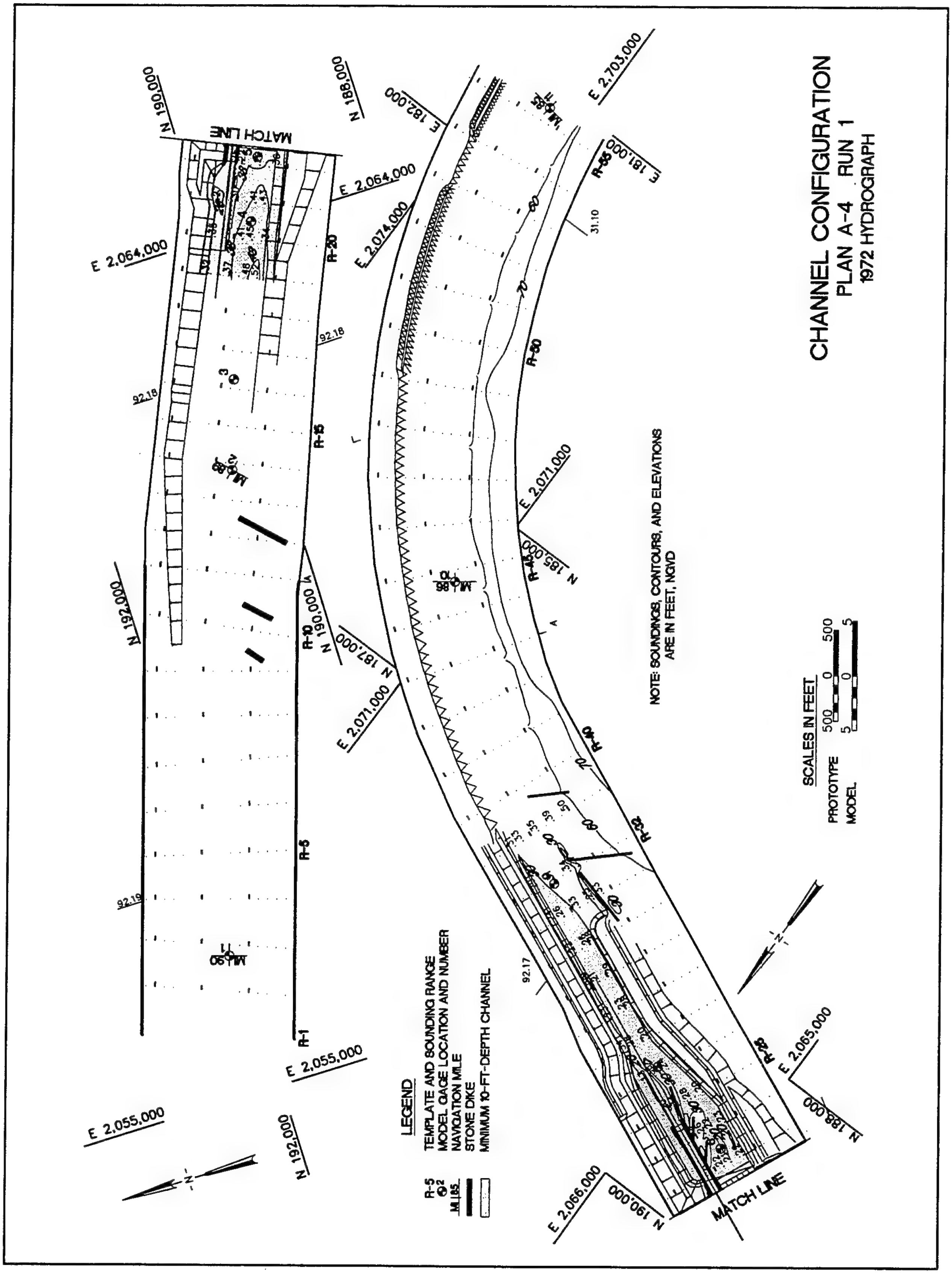
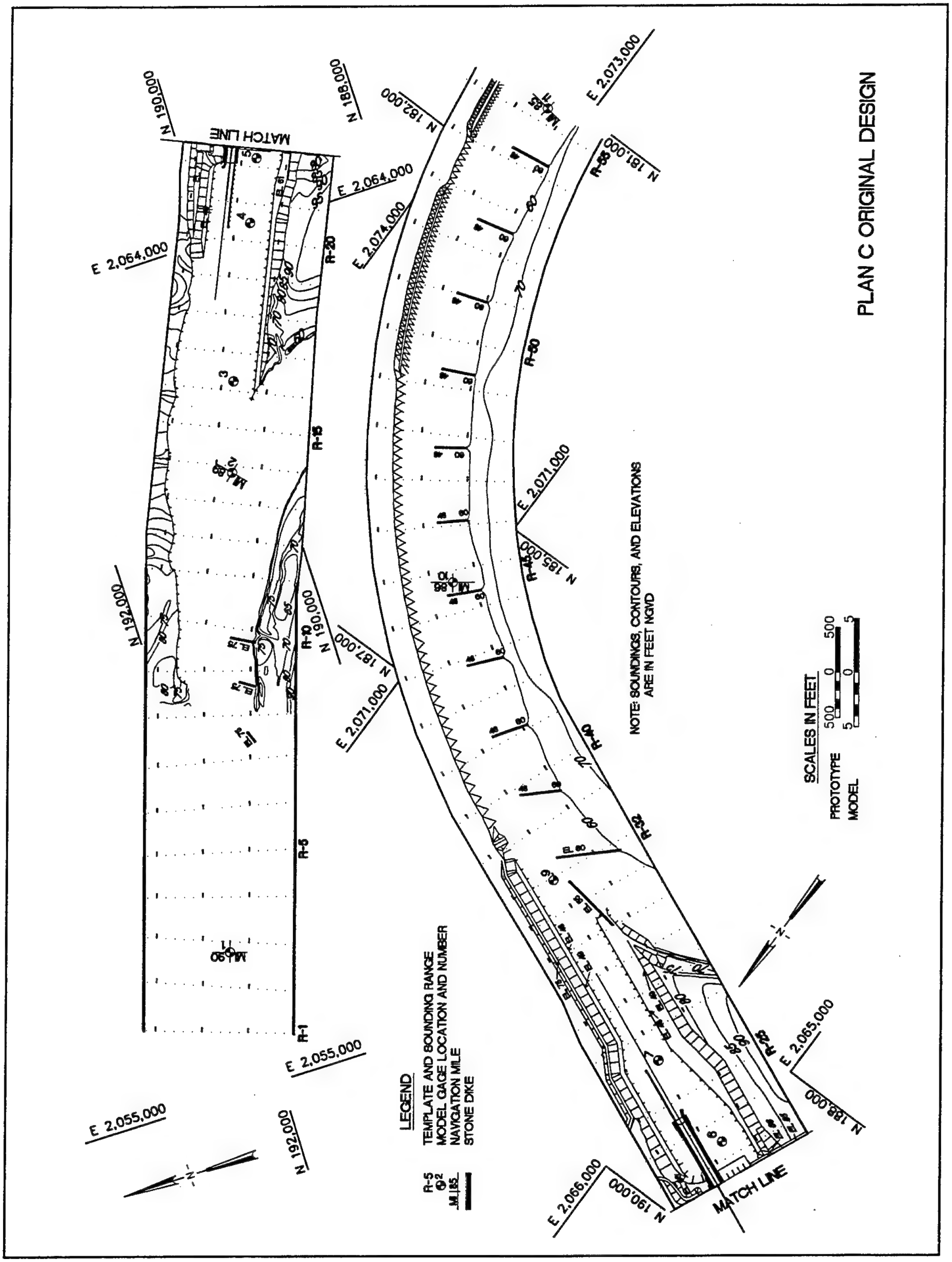
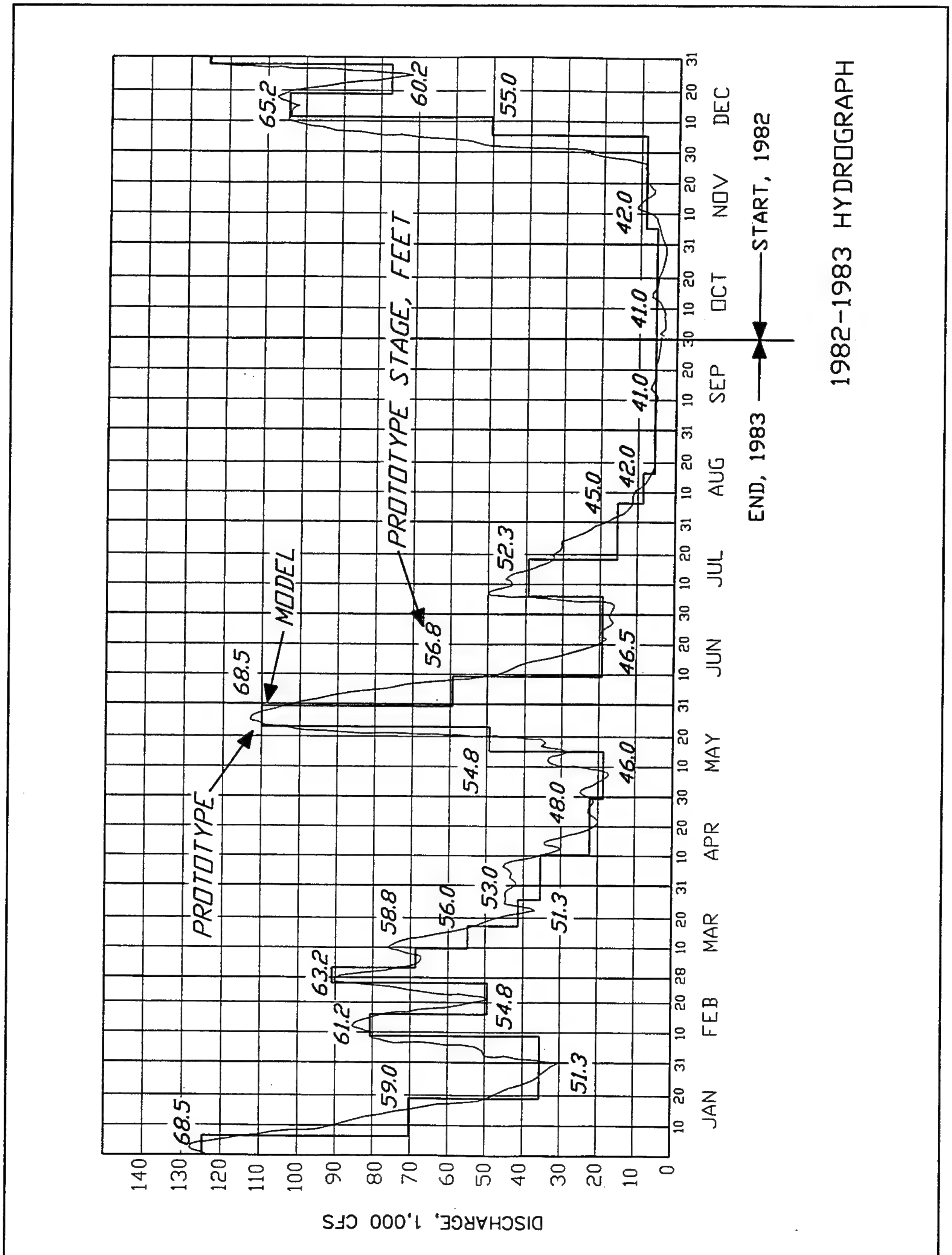
N 187,000
N 185,000



CHANNEL CONFIGURATION
PLAN B-9 RUN 1
1972 HYDROGRAPH


CHANNEL CONFIGURATION
PLAN A-4 RUN 1
1972 HYDROGRAPH
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
⊗2 MODEL GAGE LOCATION AND NUMBER
M.185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET, NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,064,000
E 2,071,000
E 2,074,000
E 2,065,000
E 2,066,000
E 2,703,000
N 192,000
N 190,000
N 188,000
N 187,000
N 185,000
N 182,000
N 181,000
R-1
R-5
R-10
R-15
R-20
R-25
R-32
R-40
R-45
R-50
R-55
92.19
92.18
92.17
31.10


PLAN C ORIGINAL DESIGN
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
2 MODEL GAGE LOCATION AND NUMBER
M.I.85 NAVIGATION MILE
STONE DIKE
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
N 192,000
N 192,000
E 2,064,000
E 2,064,000
N 190,000
N 190,000
N 188,000
N 188,000
N 187,000
E 2,071,000
E 2,071,000
E 2,074,000
N 182,000
E 2,073,000
N 181,000
N 185,000
E 2,065,000
E 2,066,000
R-1
R-5
R-10
R-15
R-20
R-25
R-32
R-40
R-45
R-50
R-55



1982-1983 HYDROGRAPH
DISCHARGE, 1,000 CFS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
PROTOTYPE
MODEL
PROTOTYPE STAGE, FEET
END, 1983
START, 1982
68.5
59.0
51.3
61.2
54.8
63.2
58.8
56.0
53.0
51.3
48.0
54.8
46.0
68.5
56.8
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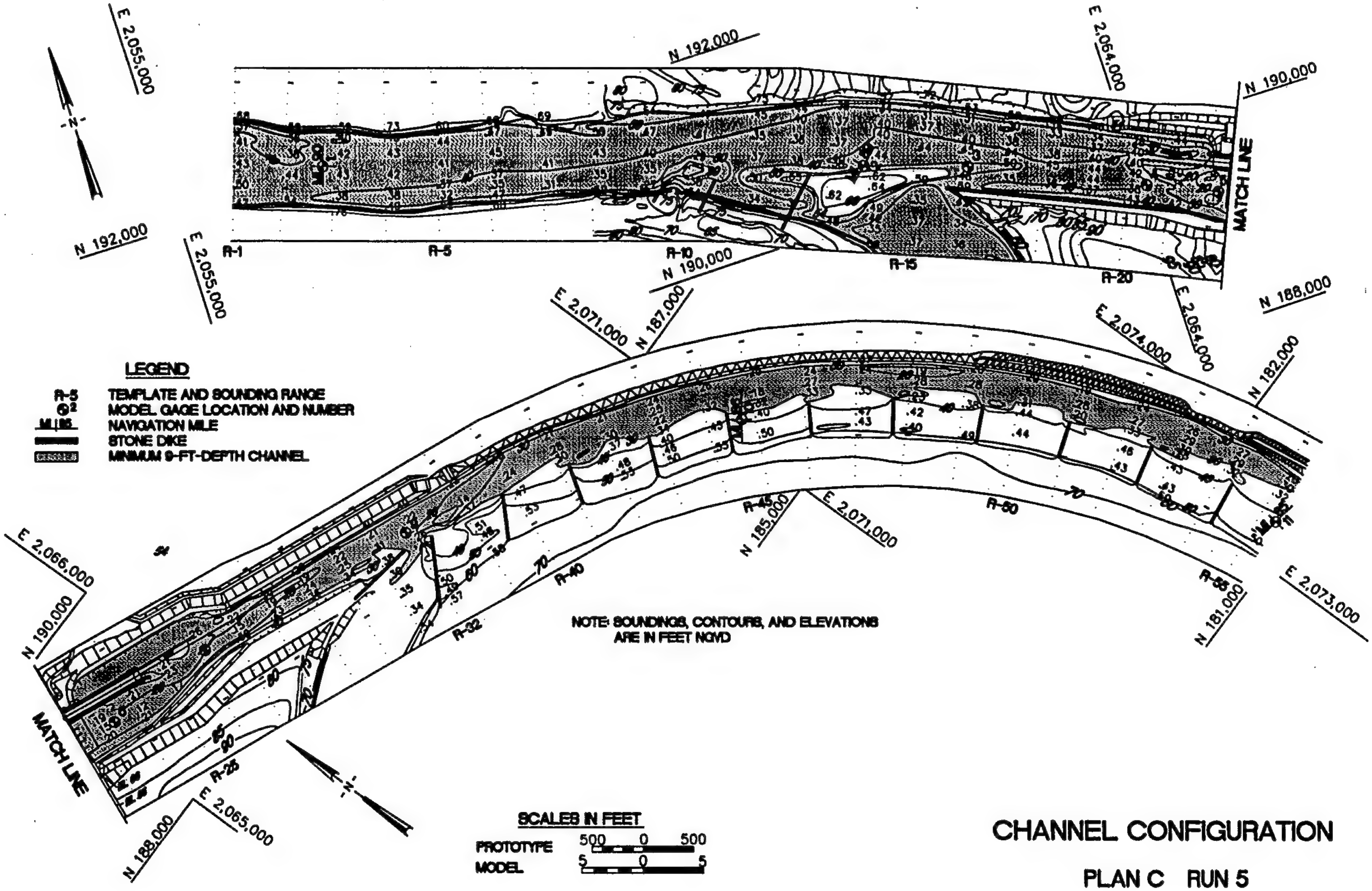
52.3
45.0
42.0
41.0
41.0
42.0
55.0
65.2
60.2



LEGEND

- R-5 TEMPLATE AND SOUNDING RANGE
- ⊕2 MODEL GAGE LOCATION AND NUMBER
- M 185 NAVIGATION MILE
- STONE DIKE
- MINIMUM 9-FT-DEPTH CHANNEL

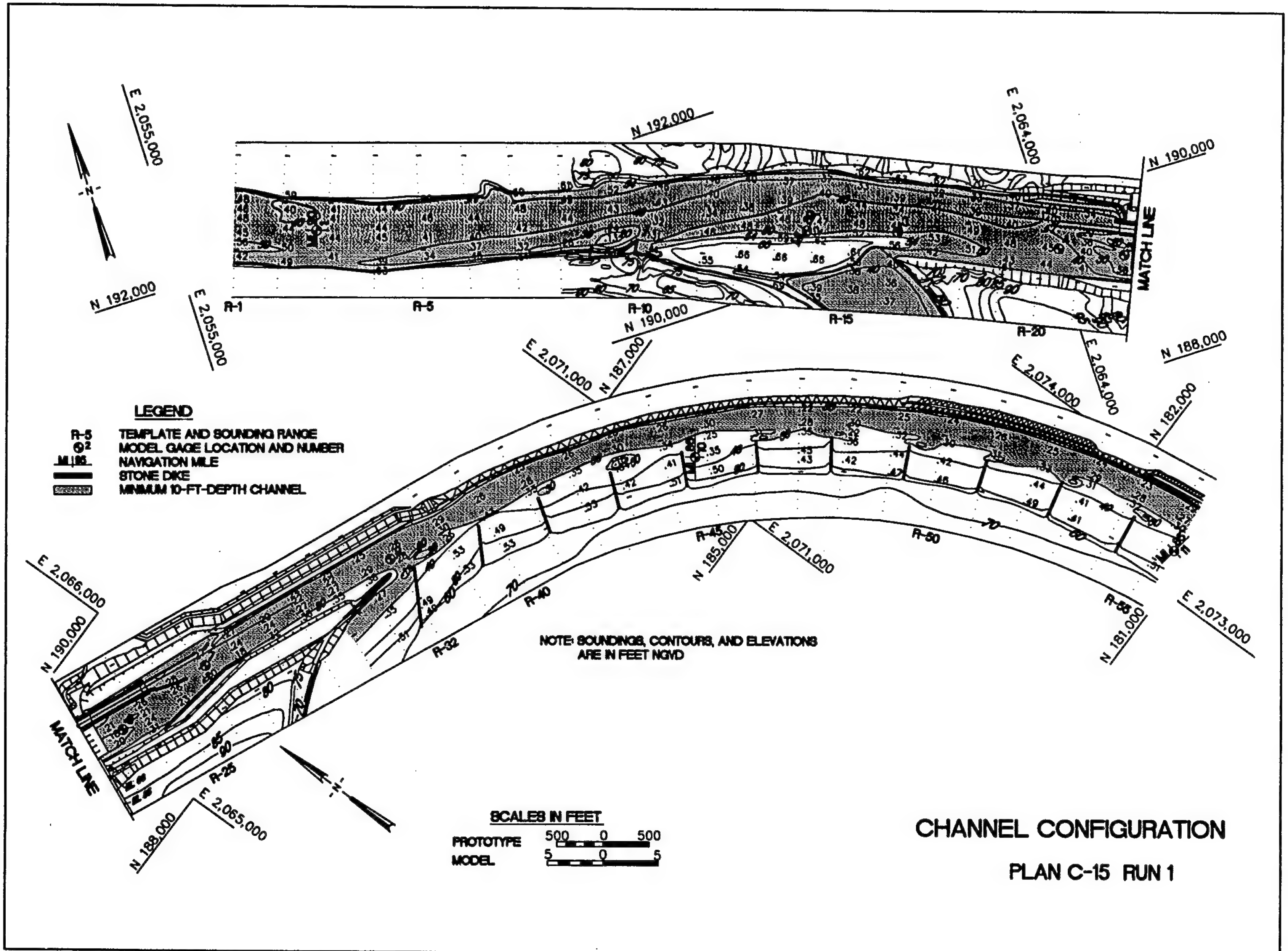
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD

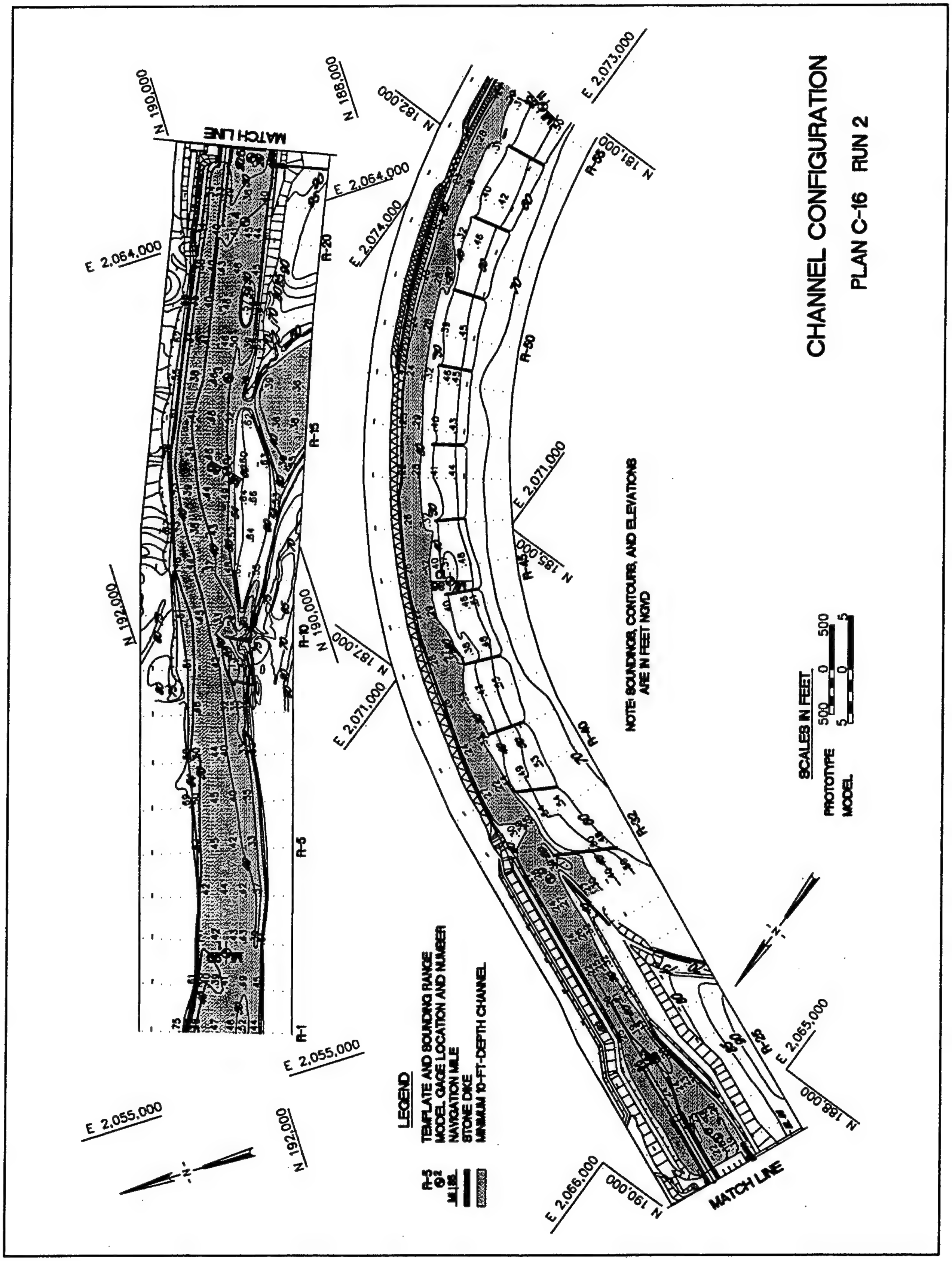
SCALES IN FEET

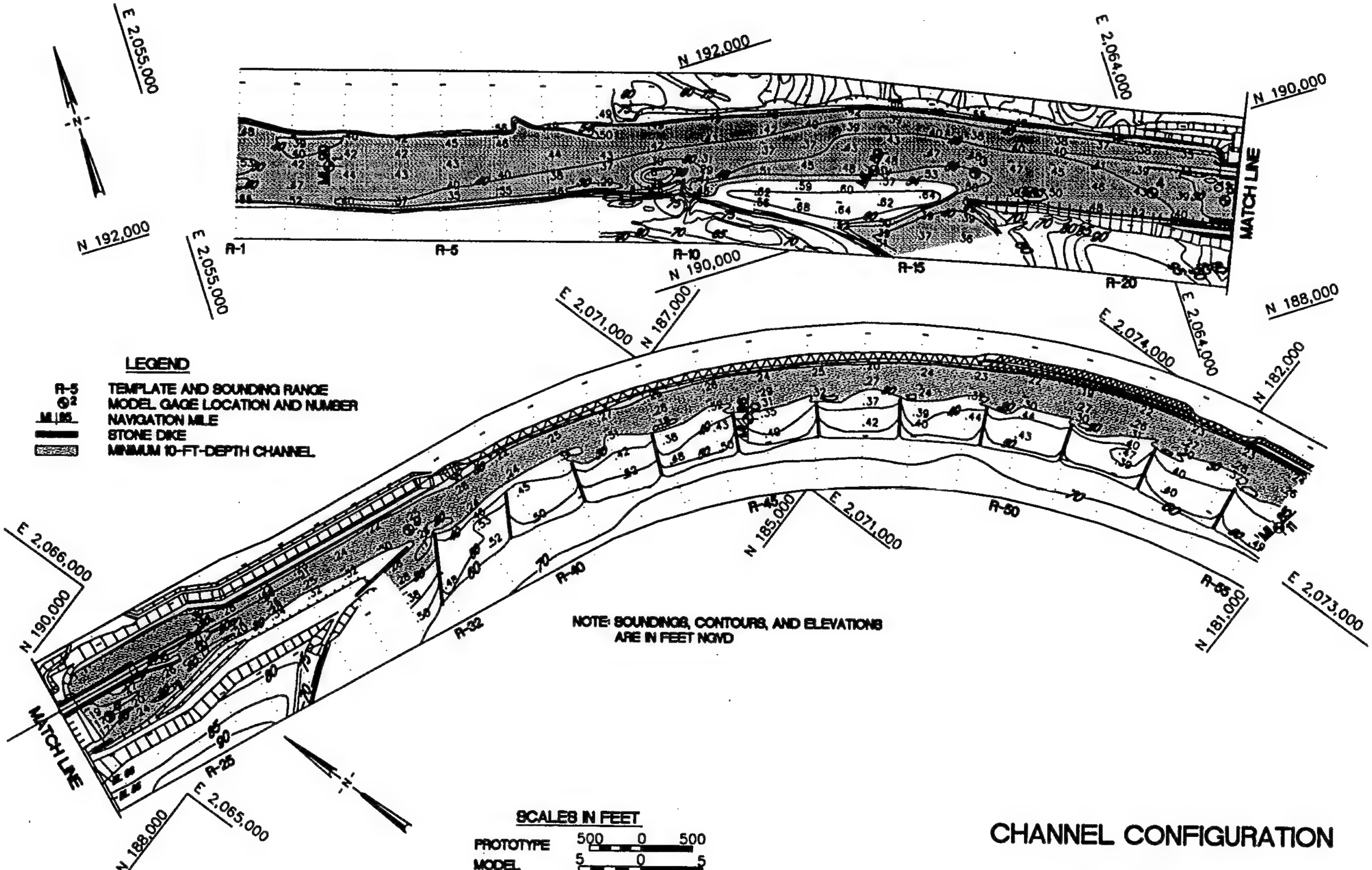
PROTOTYPE	500	0	500
MODEL	5	0	5

CHANNEL CONFIGURATION

PLAN C RUN 5

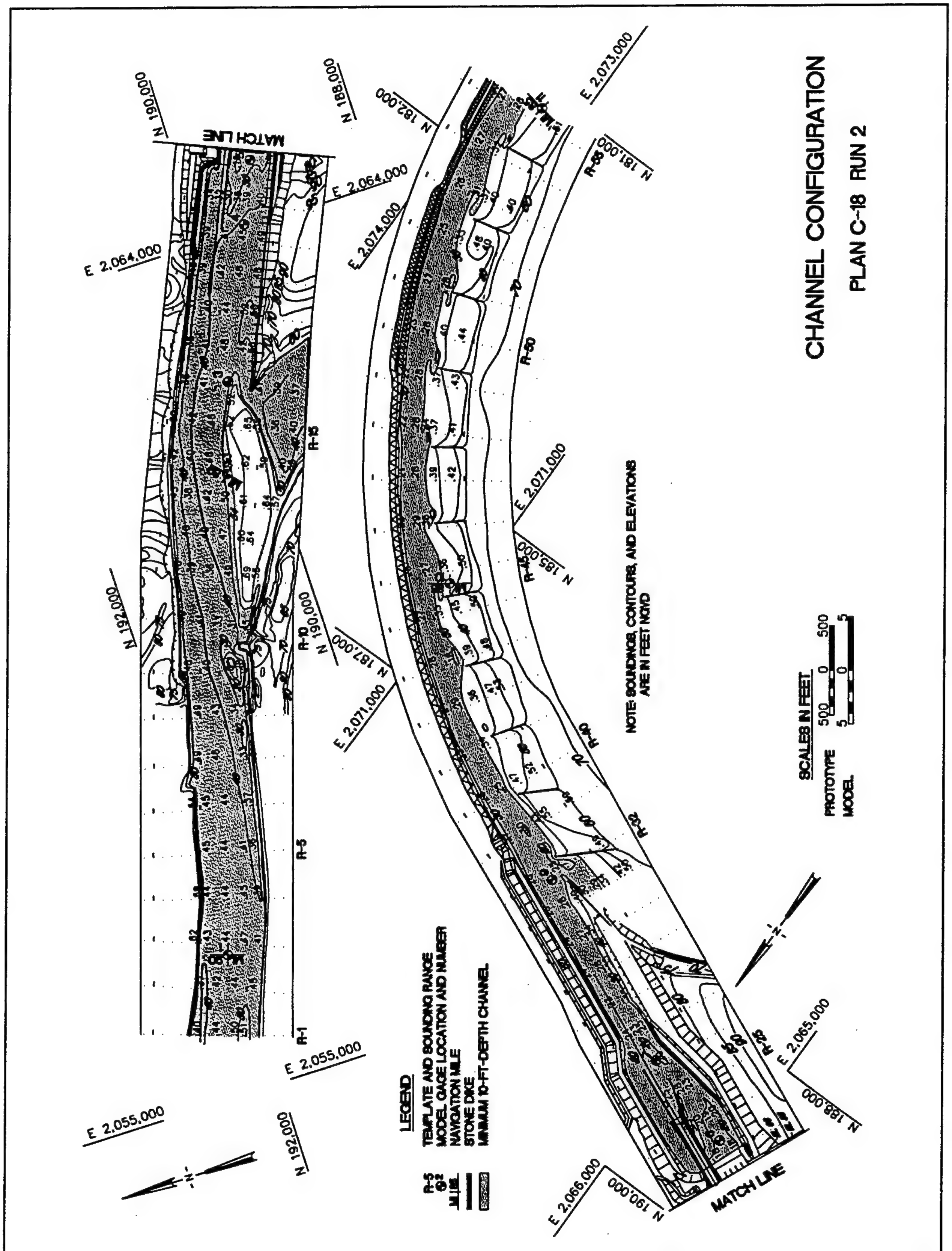

LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
N 192,000
N 190,000
N 188,000
N 187,000
N 185,000
N 182,000
N 181,000
E 2,055,000
E 2,064,000
E 2,065,000
E 2,066,000
E 2,071,000
E 2,073,000
E 2,074,000
R-1
R-5
R-10
R-15
R-20
R-25
R-32
R-40
R-45
R-50
R-55
CHANNEL CONFIGURATION
PLAN C-15 RUN 1


CHANNEL CONFIGURATION
PLAN C-16 RUN 2
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
MATCH LINE
MATCH LINE
N 190,000
N 188,000
N 192,000
N 192,000
N 190,000
N 187,000
N 182,000
N 181,000
N 185,000
N 188,000
N 190,000
E 2,064,000
E 2,064,000
E 2,055,000
E 2,055,000
E 2,074,000
E 2,073,000
E 2,071,000
E 2,071,000
E 2,065,000
E 2,066,000
R-1
R-5
R-10
R-15
R-20
R-26
R-32
R-40
R-45
R-50
R-55



CHANNEL CONFIGURATION

PLAN C-17 RUN 2


CHANNEL CONFIGURATION
PLAN C-18 RUN 2
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
G2 MODEL GAGE LOCATION AND NUMBER
M 185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
E 2,064,000
E 2,064,000
E 2,074,000
E 2,071,000
E 2,071,000
E 2,073,000
E 2,065,000
E 2,066,000
N 192,000
N 192,000
N 190,000
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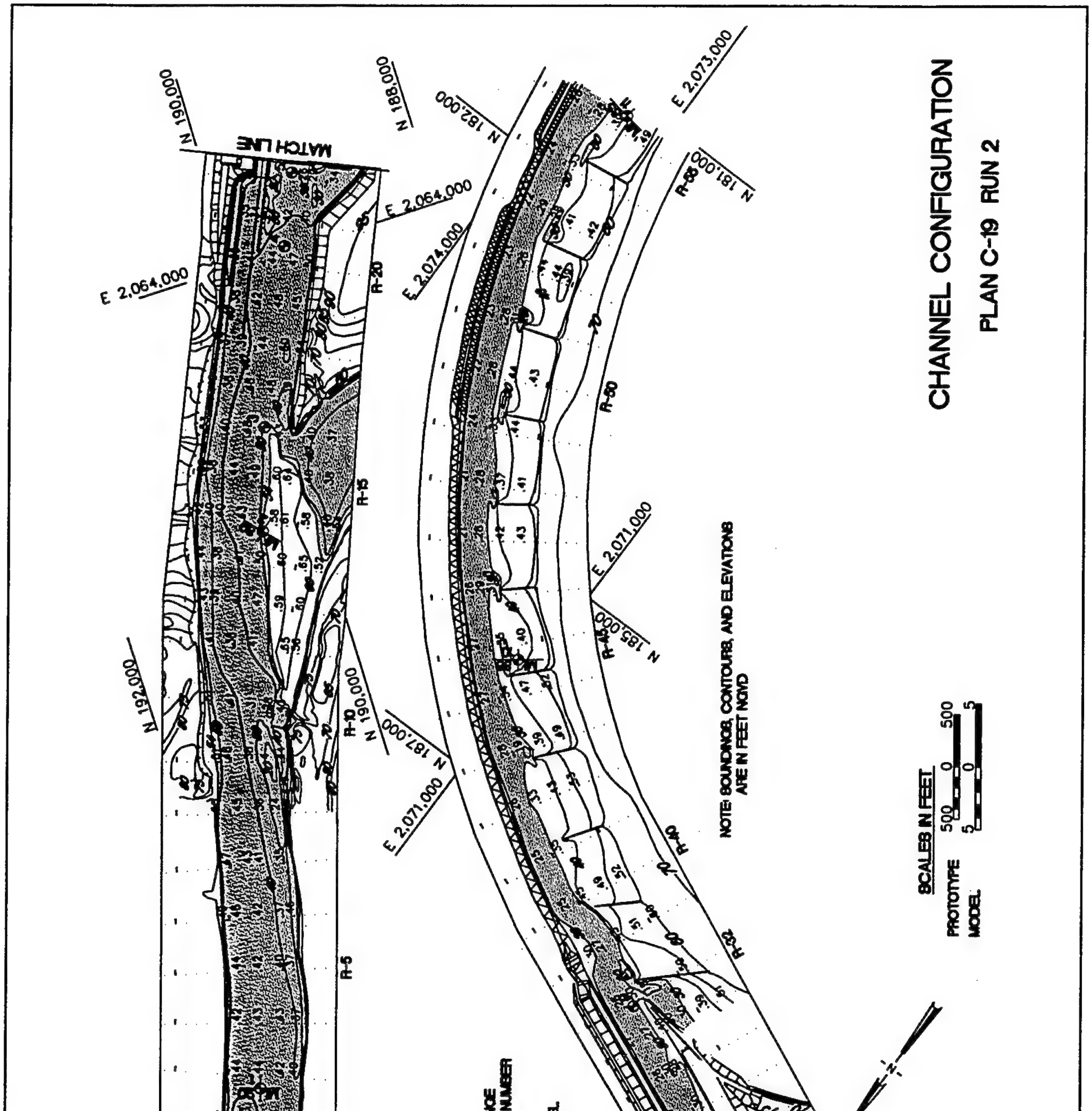
R-55



CHANNEL CONFIGURATION
PLAN C-19 RUN 2
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
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MODEL 5 0 5
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
N 192,000
N 192,000
E 2,064,000
E 2,064,000
N 190,000
N 188,000
E 2,074,000
E 2,073,000
N 182,000
N 181,000
E 2,071,000
E 2,071,000
N 187,000
N 185,000
E 2,065,000
N 188,000
E 2,066,000
N 190,000
R-1
R-5
R-10
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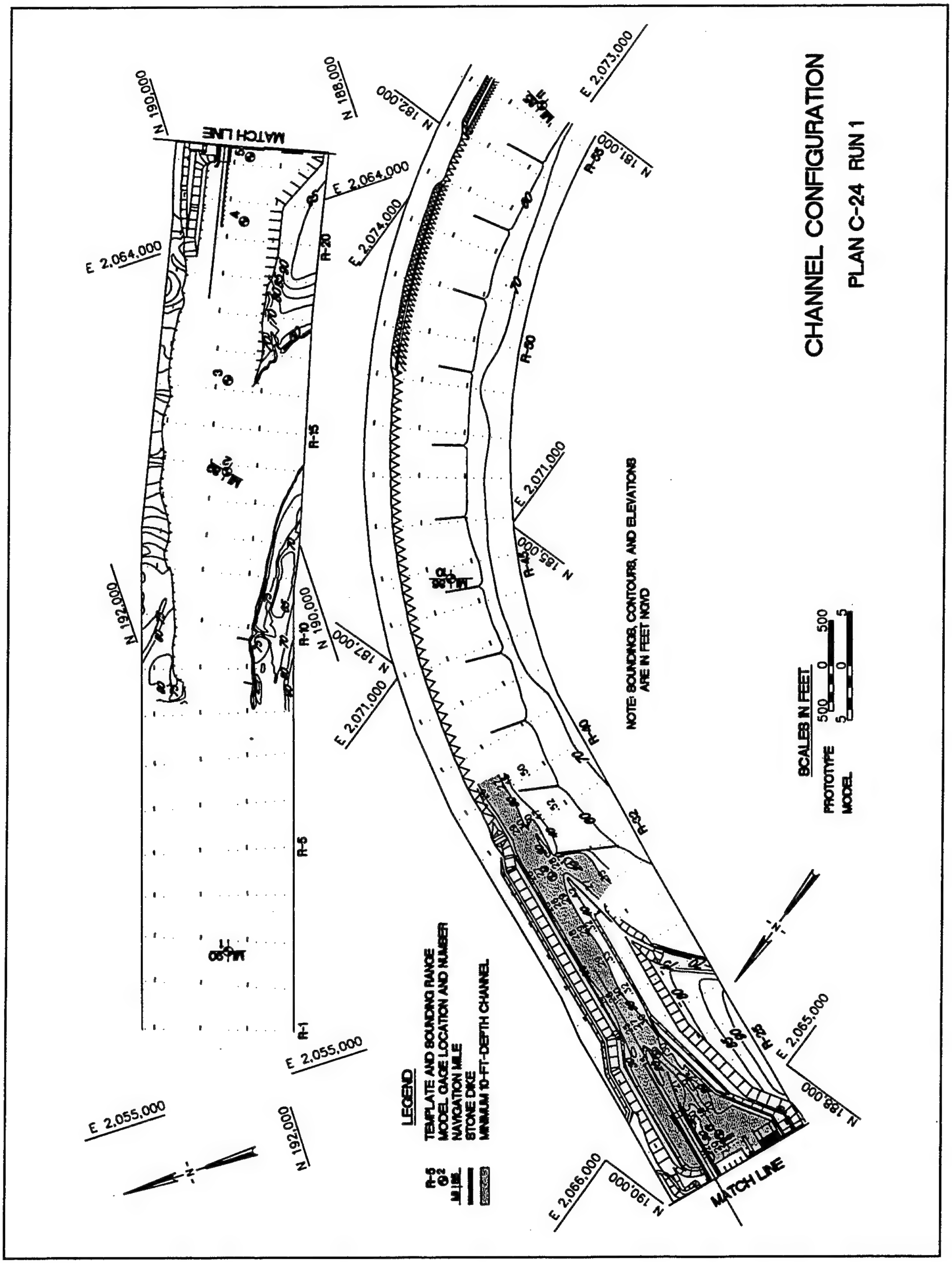
R-25
R-30
R-40
R-45
R-50
R-55


CHANNEL CONFIGURATION
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MODEL 5 0 5
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
⊕2 MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
MATCH LINE
MATCH LINE
N 190,000
N 188,000
N 192,000
N 187,000
N 185,000
N 182,000
N 181,000
N 189,000
E 2,064,000
E 2,055,000
E 2,071,000
E 2,073,000
E 2,074,000
E 2,065,000
E 2,066,000
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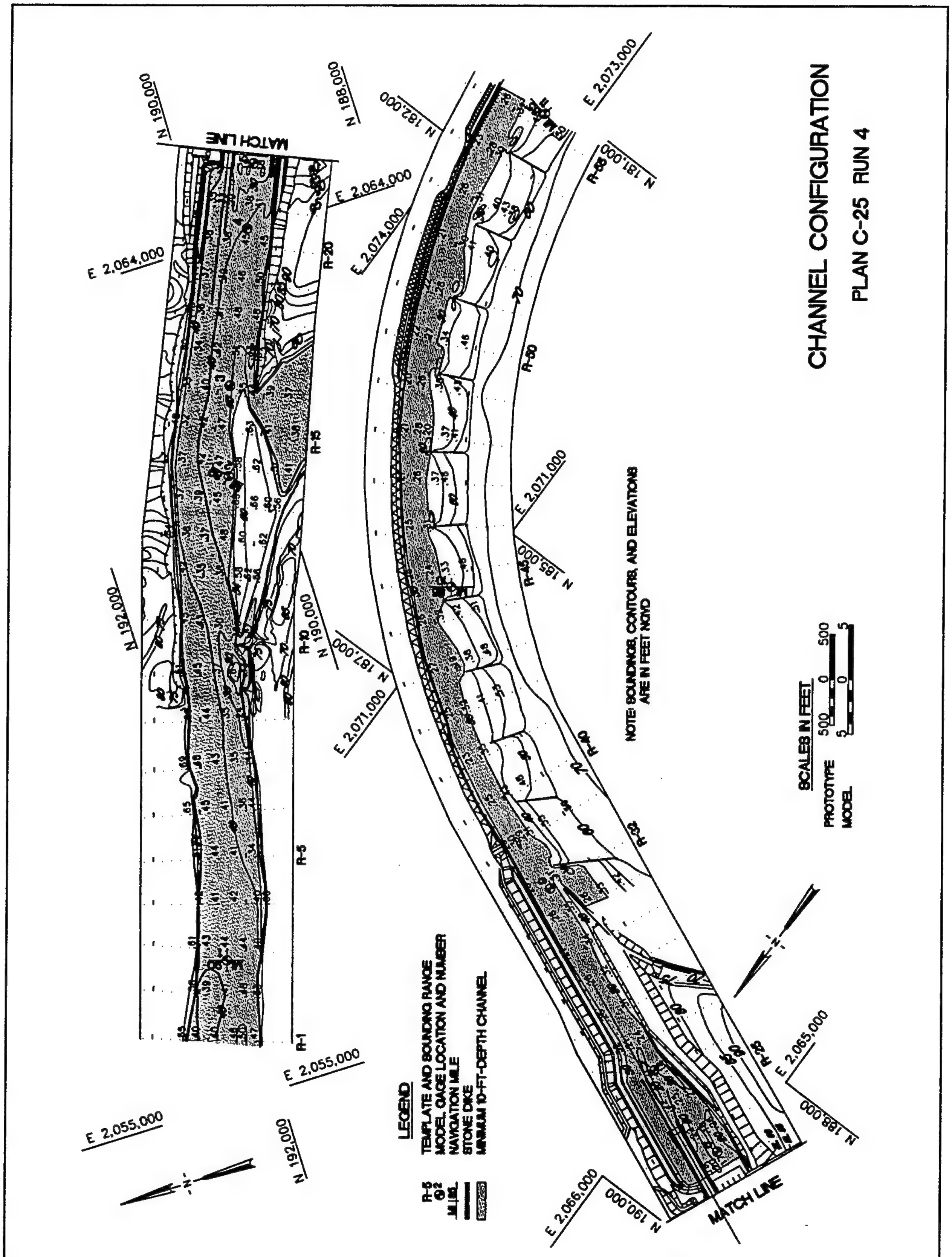
N


CHANNEL CONFIGURATION
PLAN C-25 RUN 4
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
⊕2 MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
E 2,064,000
E 2,064,000
E 2,071,000
E 2,071,000
E 2,073,000
E 2,074,000
E 2,065,000
E 2,066,000
N 192,000
N 192,000
N 190,000
N 190,000
N 190,000
N 188,000
N 188,000
N 187,000
N 185,000
N 182,000
N 181,000
R-1
R-5
R-10
R-15
R-20
R-25
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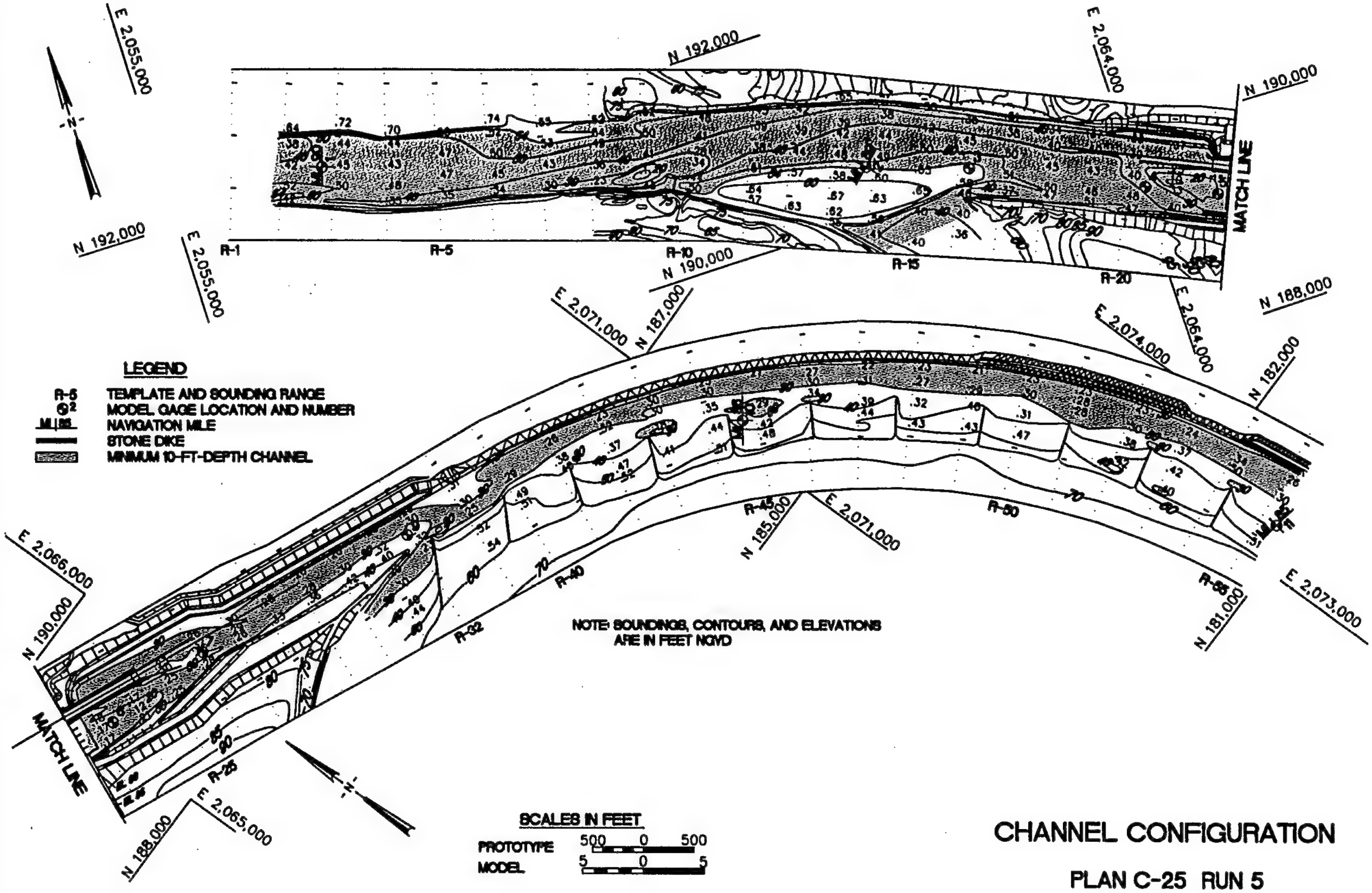
R-40
R-45
R-50
R-55



LEGEND

R-5 TEMPLATE AND SOUNDING RANGE
⊙2 MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL

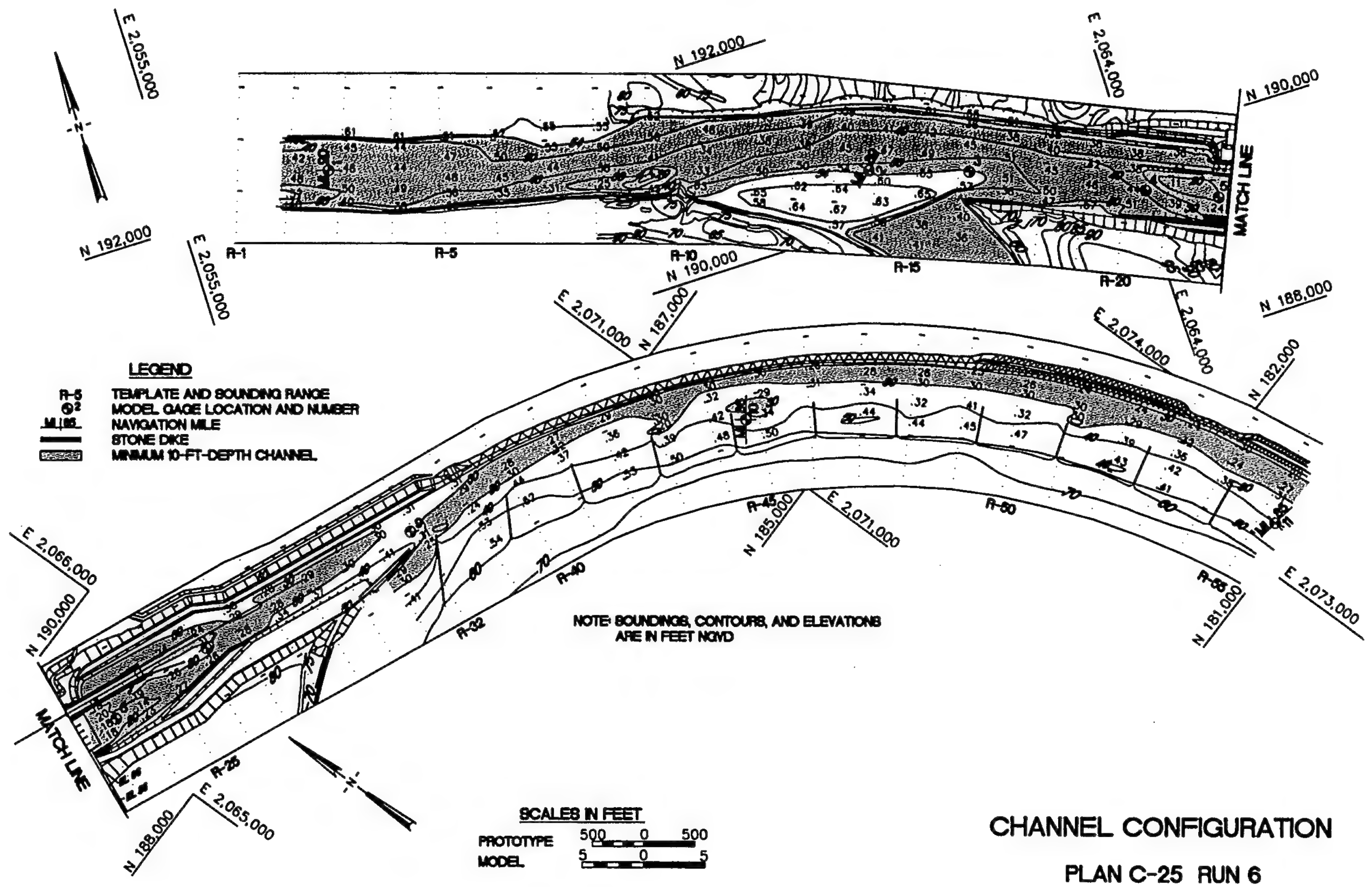
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD

SCALES IN FEET

PROTOTYPE 500 0 500
MODEL 5 0 5

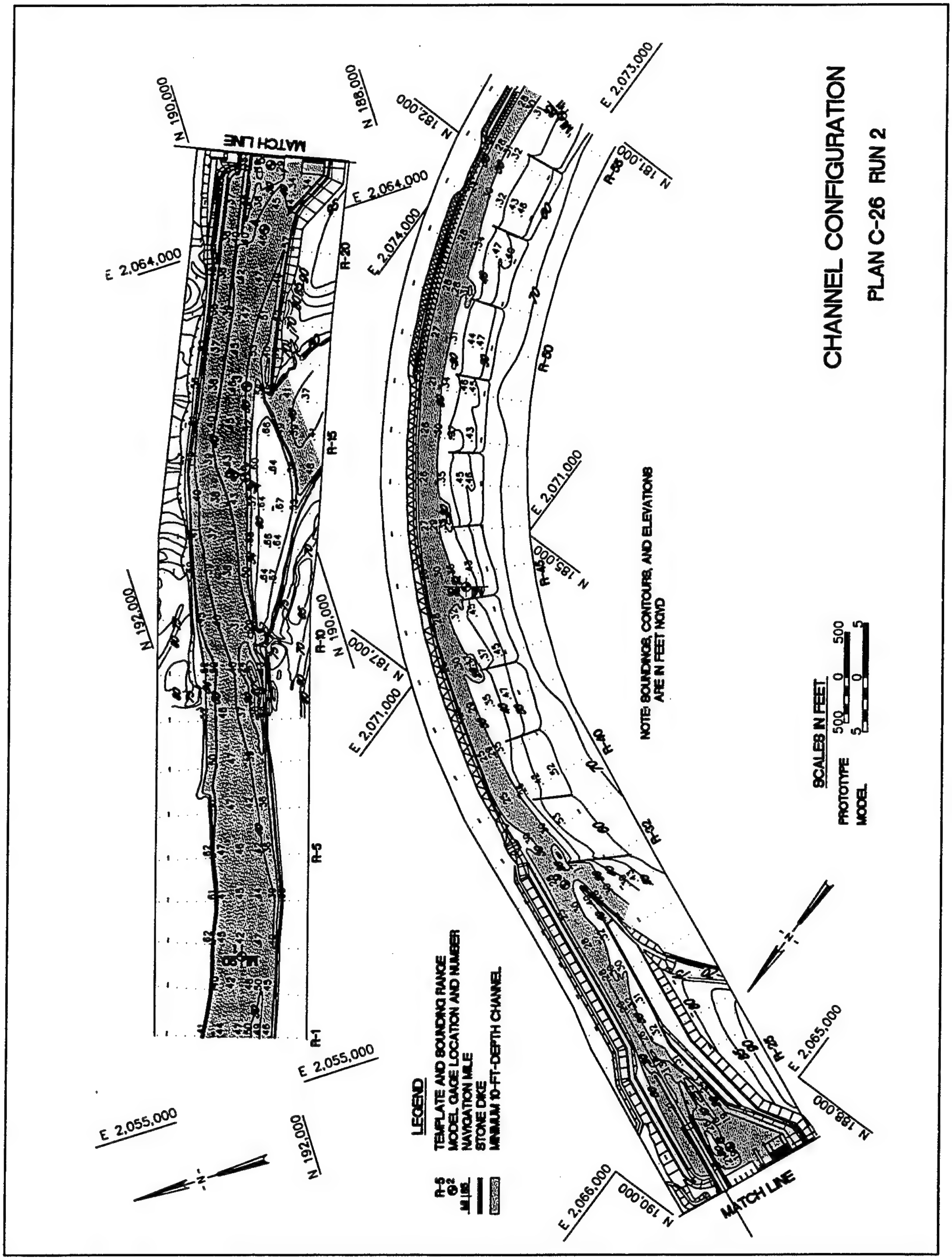
CHANNEL CONFIGURATION

PLAN C-25 RUN 5



CHANNEL CONFIGURATION

PLAN C-25 RUN 6


CHANNEL CONFIGURATION
PLAN C-26 RUN 2
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
G2 MODEL GAGE LOCATION AND NUMBER
MI 185 NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
MATCH LINE
MATCH LINE
E 2,055,000
E 2,055,000
N 192,000
N 192,000
E 2,064,000
E 2,064,000
N 190,000
N 190,000
N 188,000
N 188,000
E 2,071,000
E 2,071,000
N 187,000
N 185,000
N 182,000
N 181,000
E 2,073,000
E 2,074,000
E 2,065,000
E 2,066,000
R-1
R-5
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R-20
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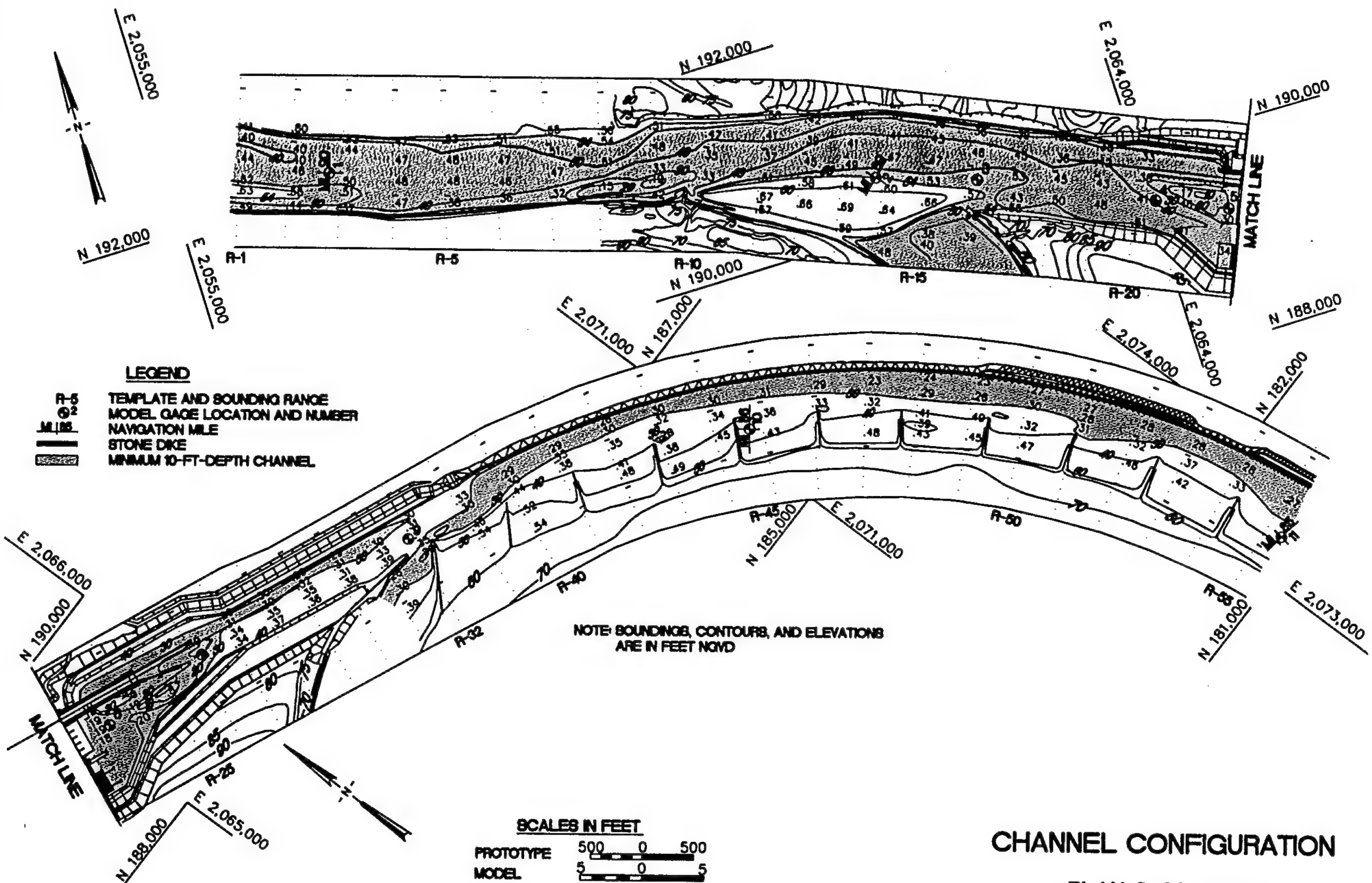
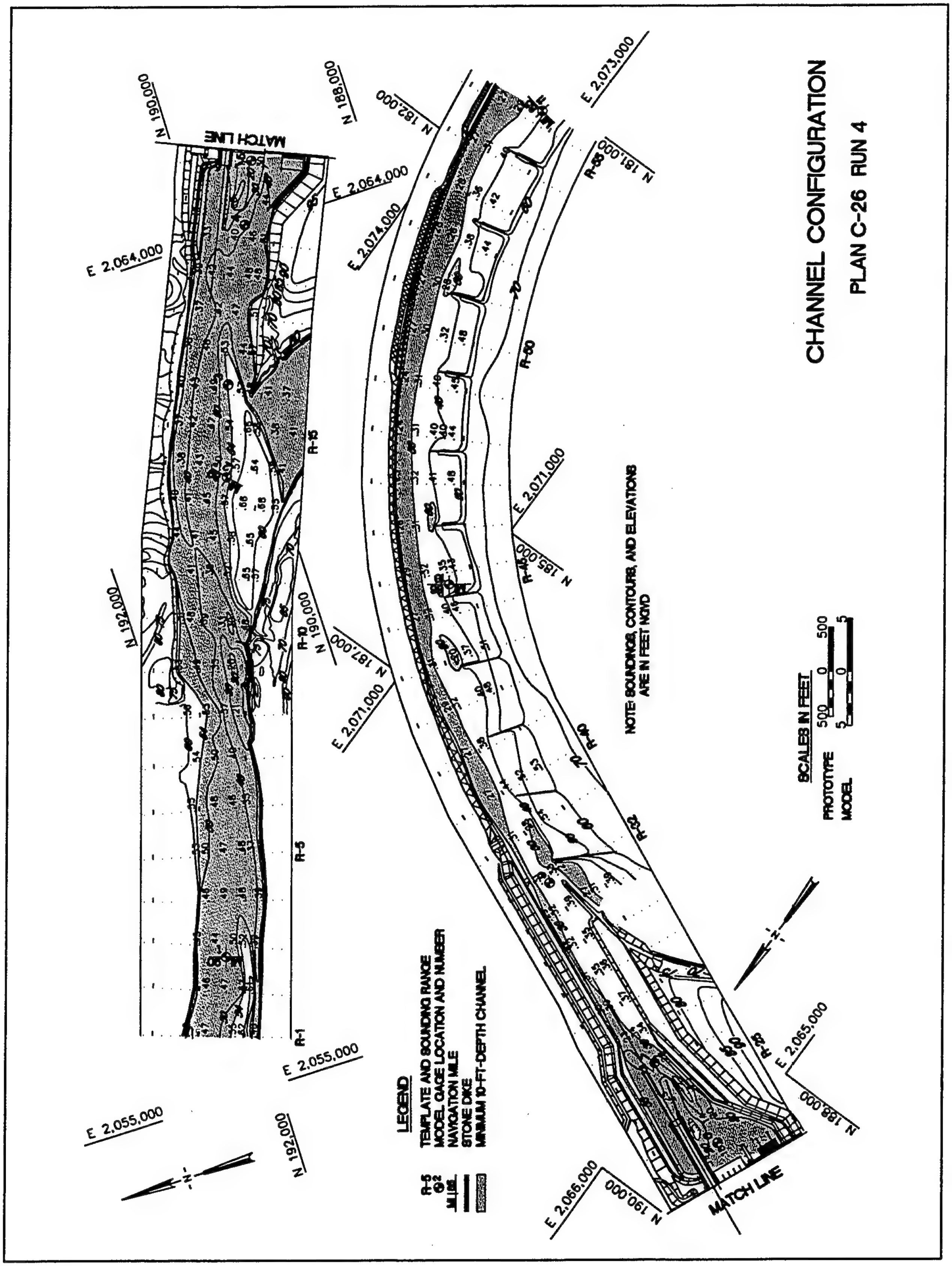
R-40
R-45
R-50
R-55

Plate 28



CHANNEL CONFIGURATION

PLAN C-26 RUN 3



CHANNEL CONFIGURATION
PLAN C-26 RUN 4
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
MATCH LINE
MATCH LINE
E 2,064,000
E 2,064,000
E 2,055,000
E 2,055,000
E 2,071,000
E 2,071,000
E 2,073,000
E 2,074,000
E 2,065,000
E 2,066,000
N 190,000
N 190,000
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N 192,000
N 192,000
N 188,000
N 188,000
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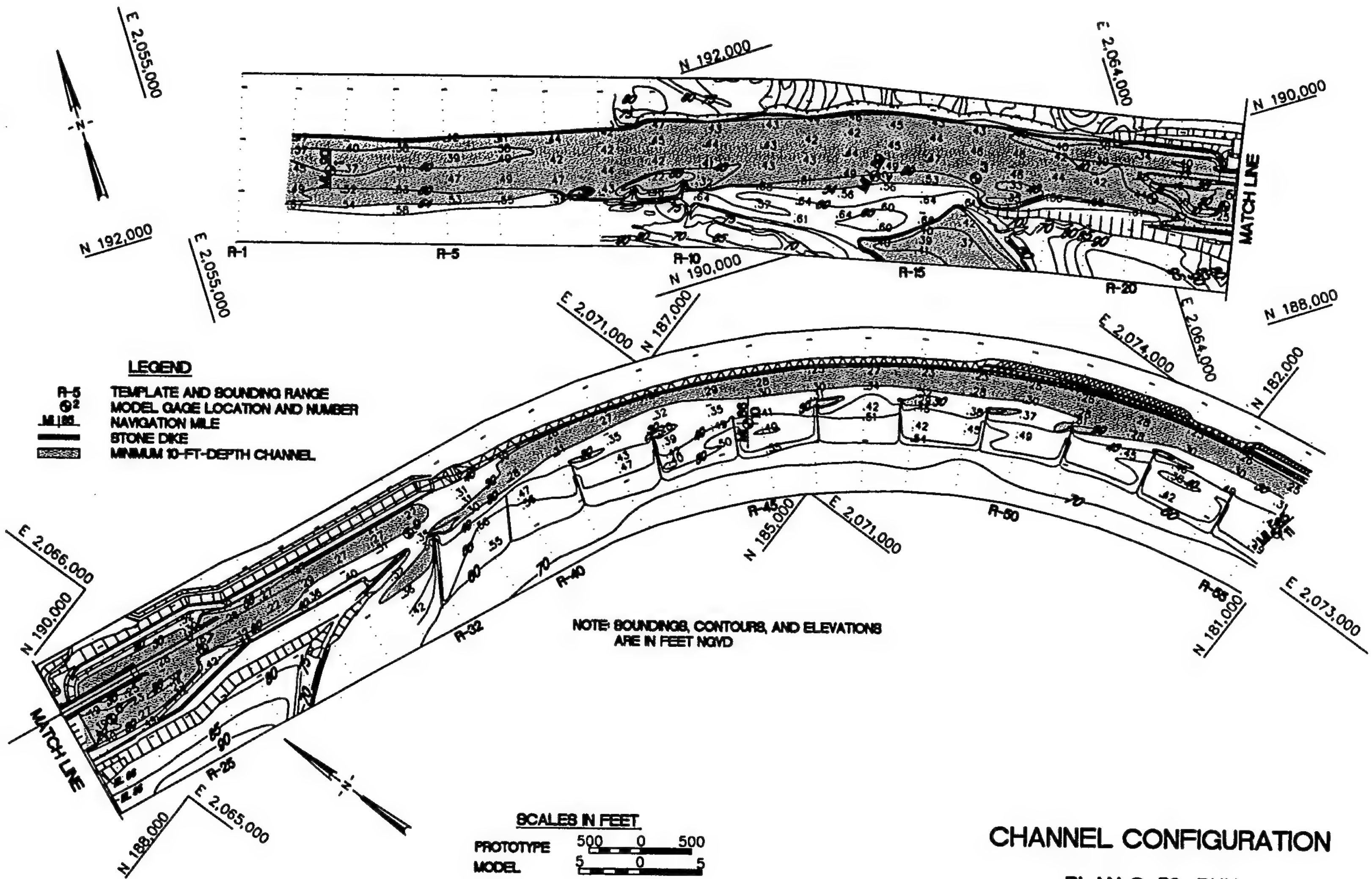
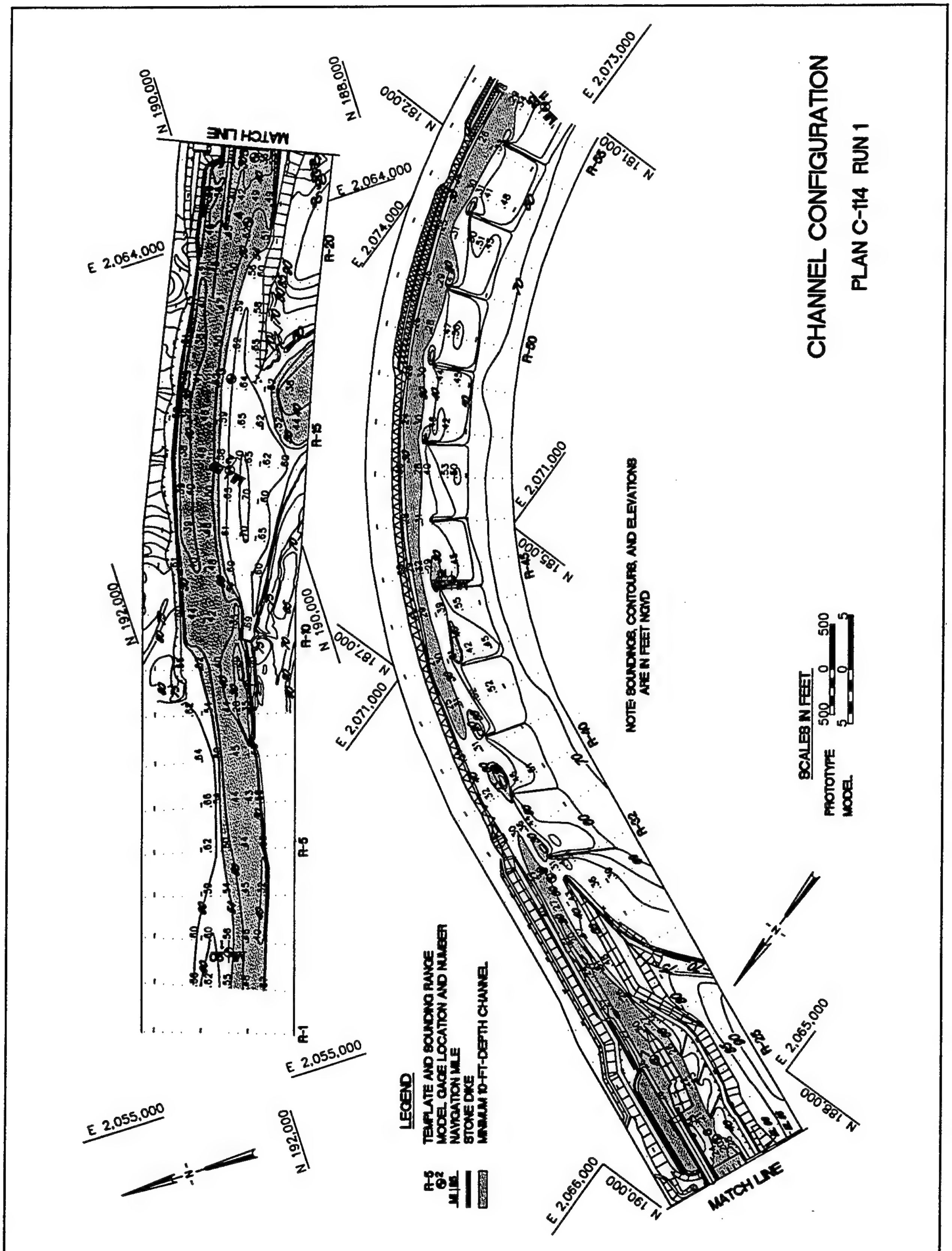
N 185,000
N 182,000
N 181,000
R-1
R-5
R-10
R-15
R-25
R-32
R-40
R-45
R-50
R-55

Plate 30



CHANNEL CONFIGURATION

PLAN C-50 RUN 6


CHANNEL CONFIGURATION
PLAN C-114 RUN 1
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
MATCH LINE
MATCH LINE
N 190,000
N 188,000
N 182,000
N 181,000
N 192,000
N 190,000
N 187,000
N 185,000
N 192,000
N 188,000
N 190,000
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E 2,055,000
E 2,055,000
E 2,065,000
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R-1
R-5
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R-20
R-26
R-32
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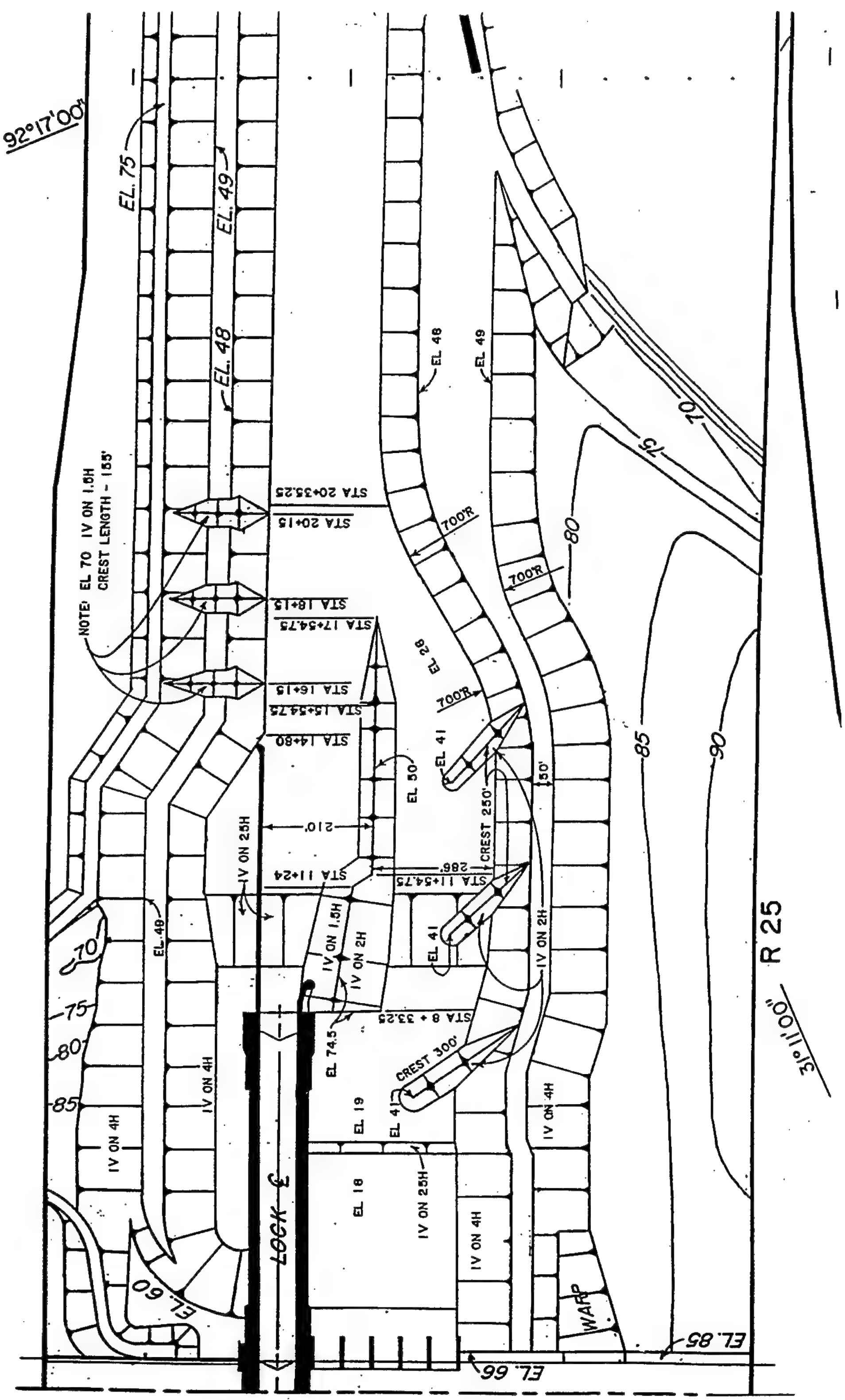
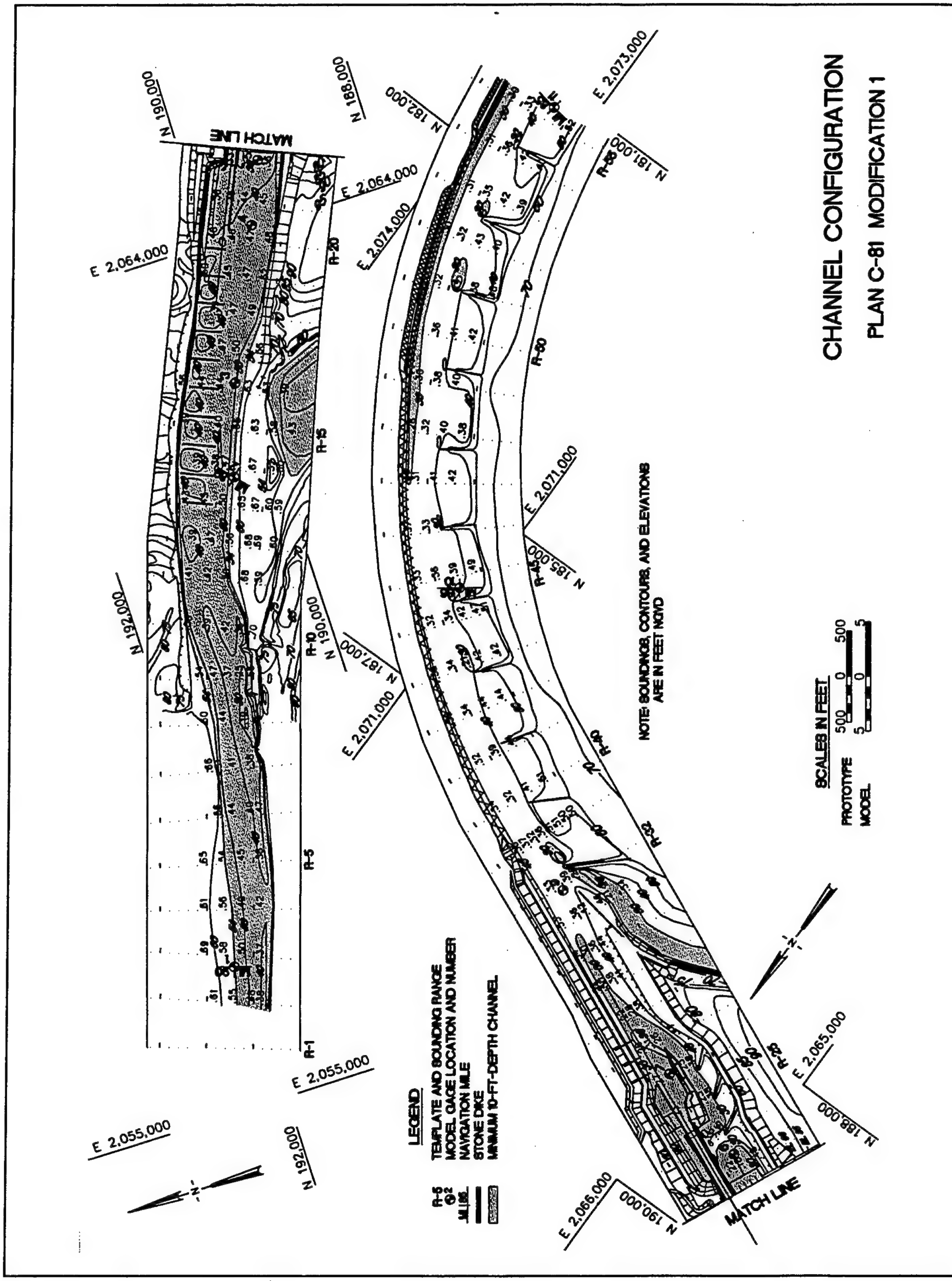
R-50
R-55

Plate 32



CONTRACTION WORKS SYSTEM
PLAN C-81


CHANNEL CONFIGURATION
PLAN C-81 MODIFICATION 1
LEGEND
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE 500 0 500
MODEL 5 0 5
MATCH LINE
MATCH LINE
E 2,055,000
E 2,064,000
E 2,065,000
E 2,066,000
E 2,071,000
E 2,073,000
E 2,074,000
N 181,000
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N 190,000
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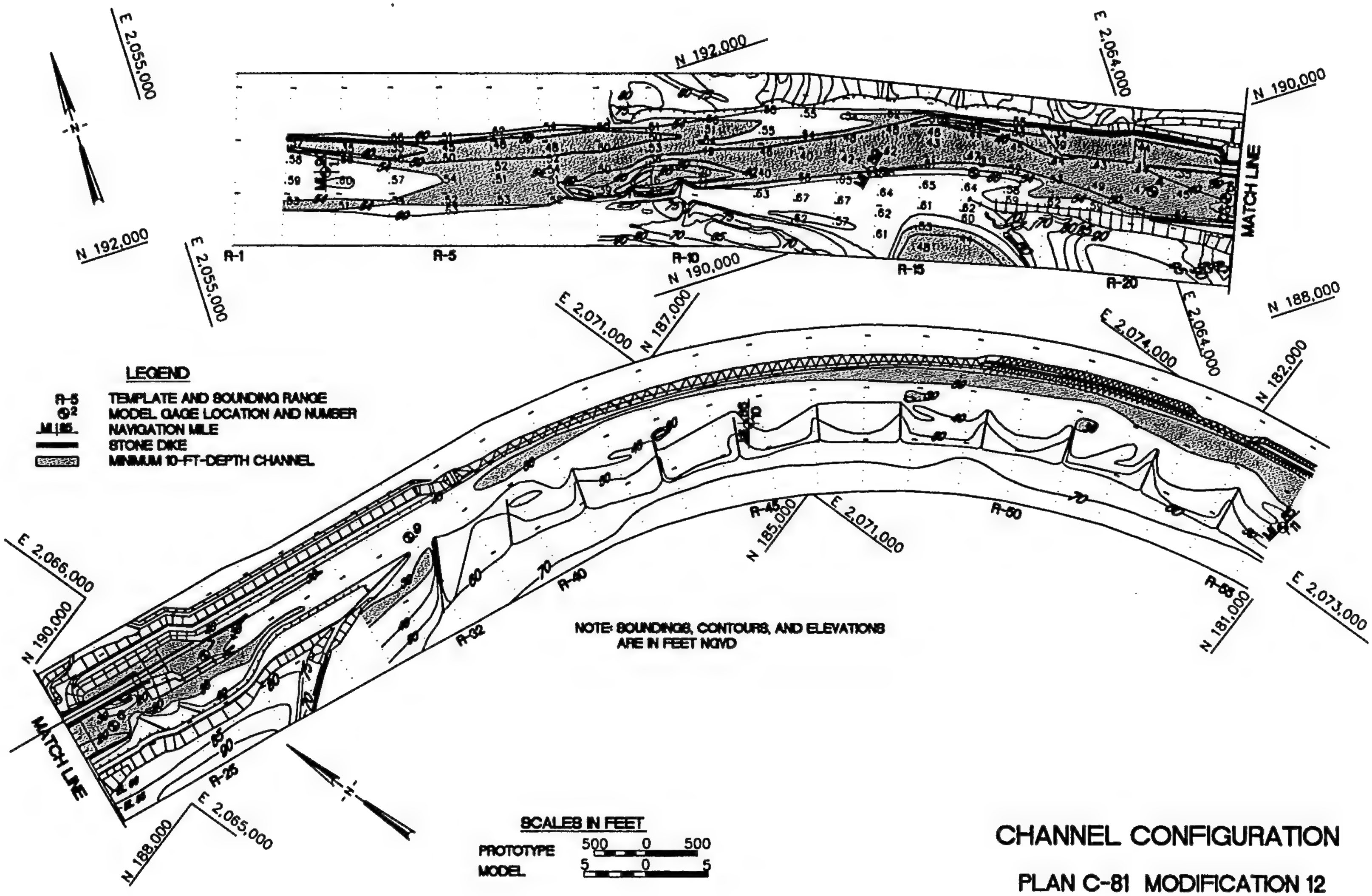
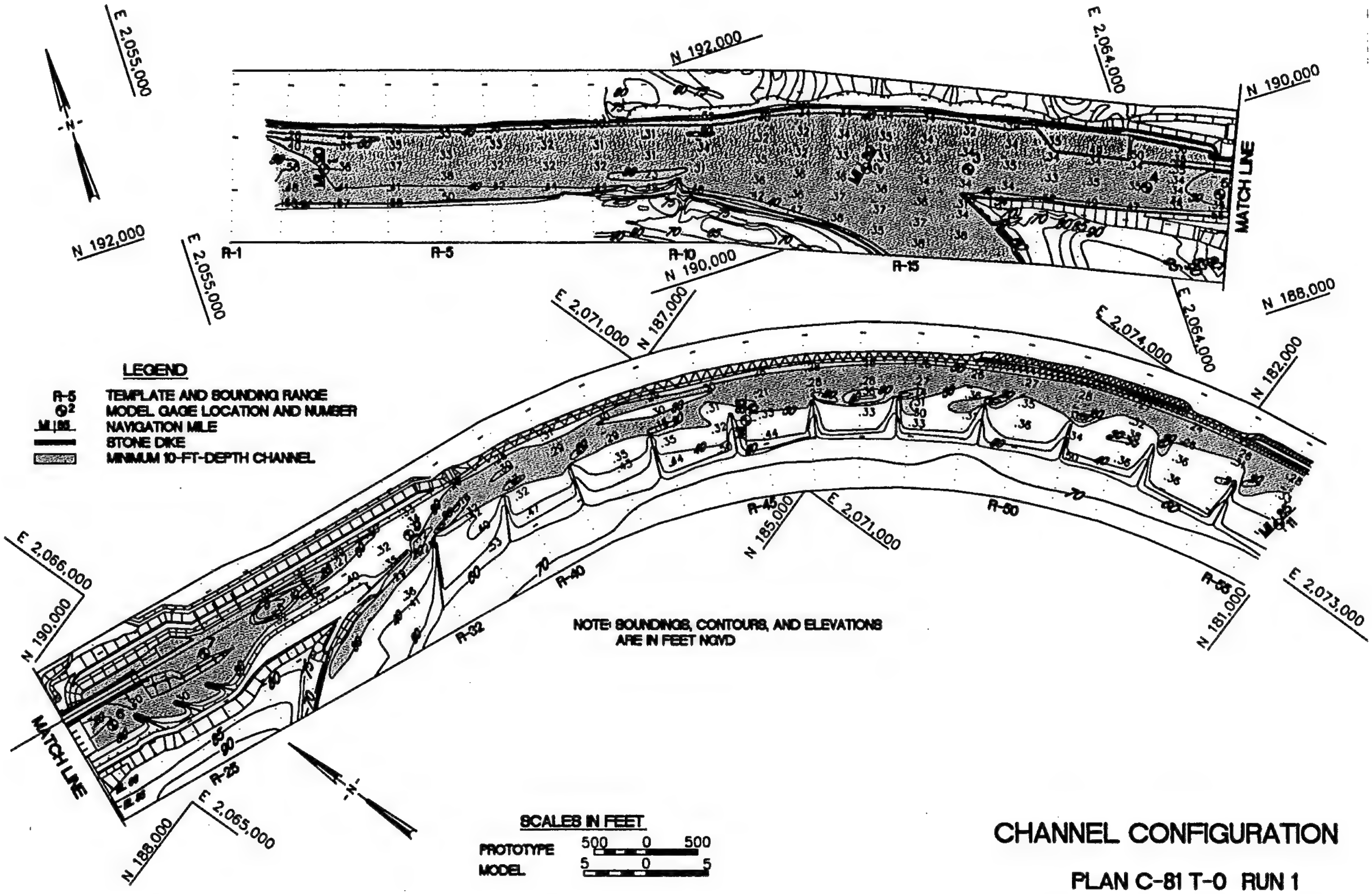
R-1
R-5
R-10
R-15
R-20

Plate 34



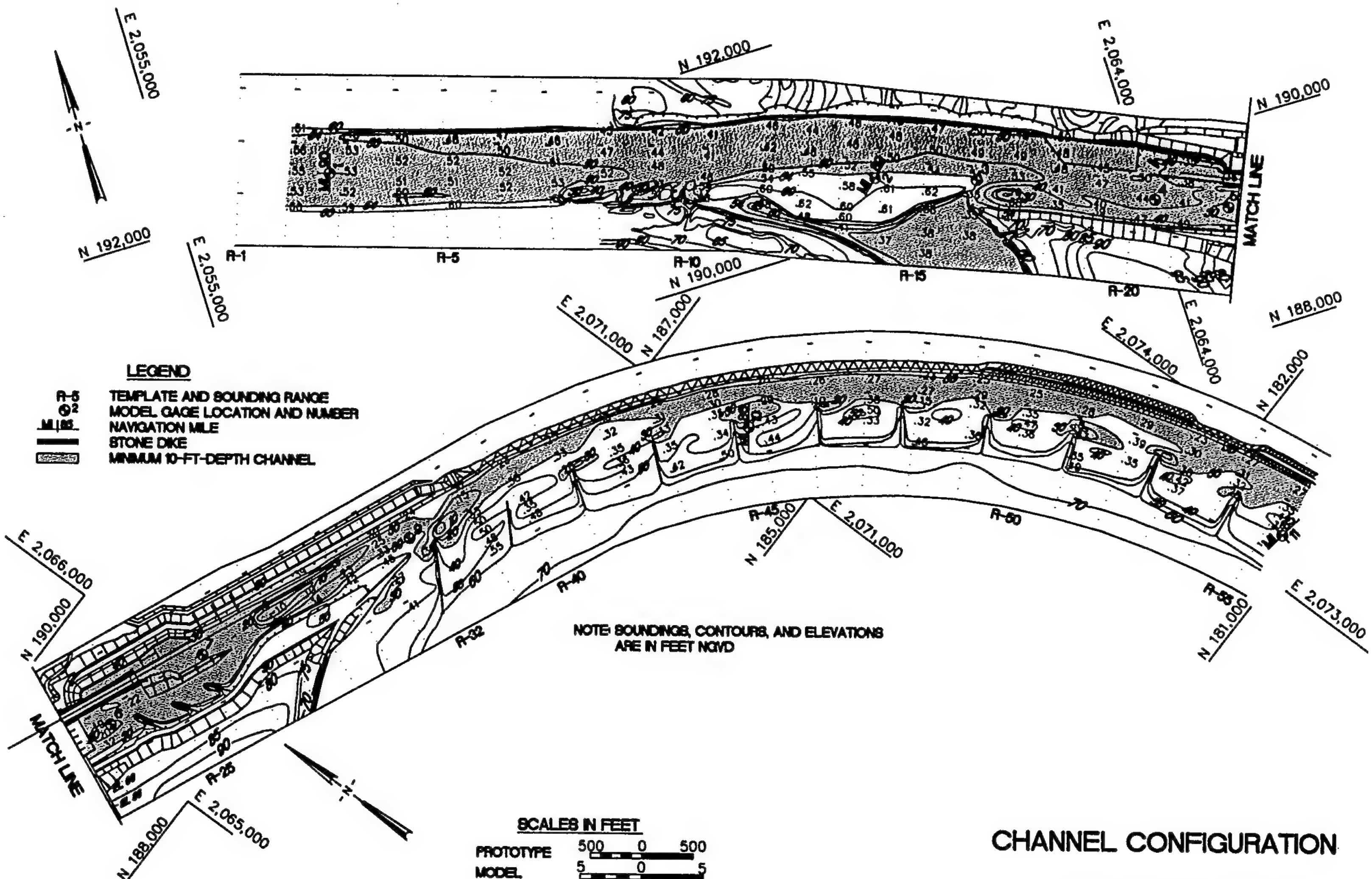
CHANNEL CONFIGURATION

PLAN C-81 MODIFICATION 12



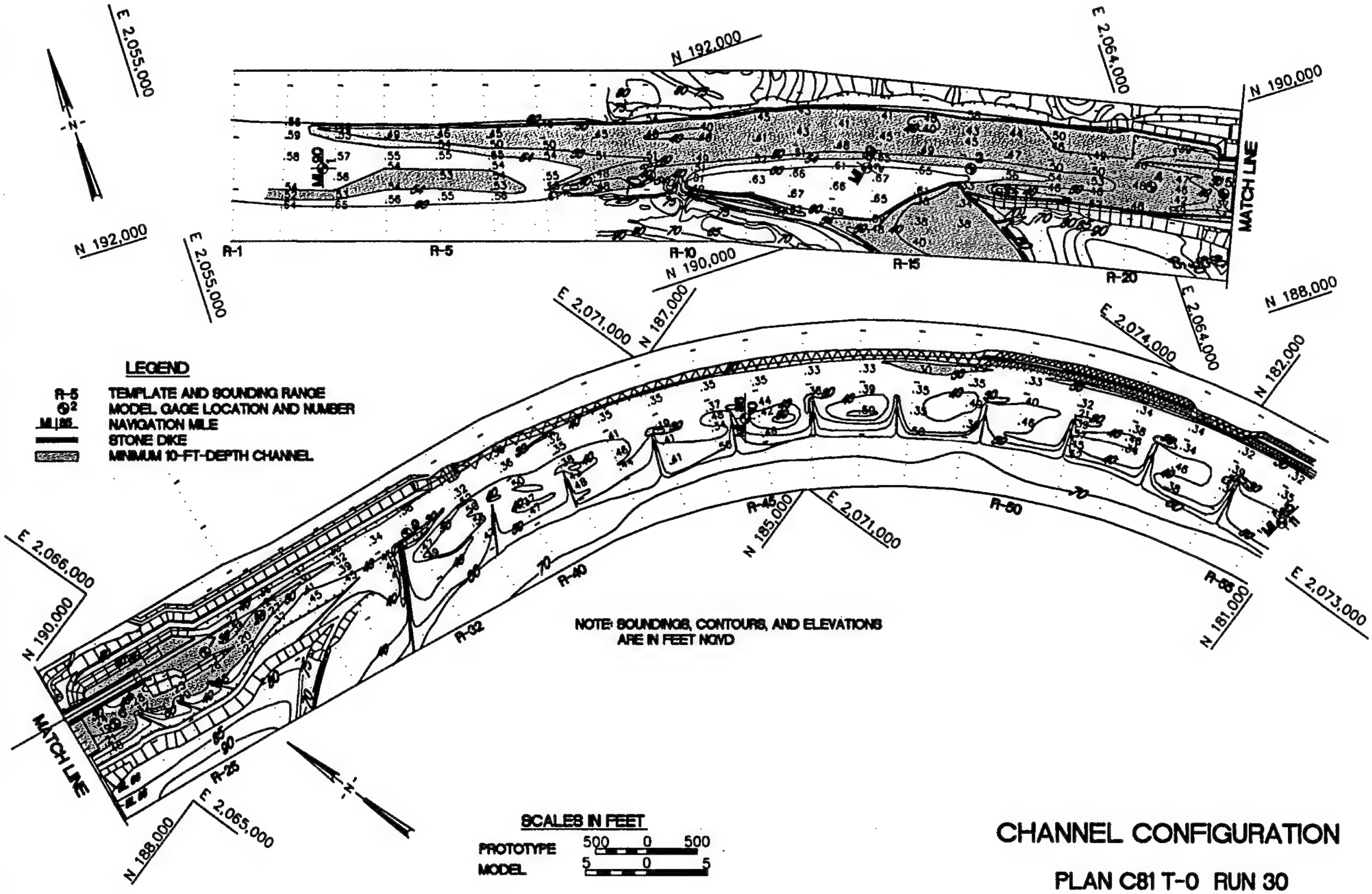
CHANNEL CONFIGURATION

PLAN C-81 T-0 RUN 1



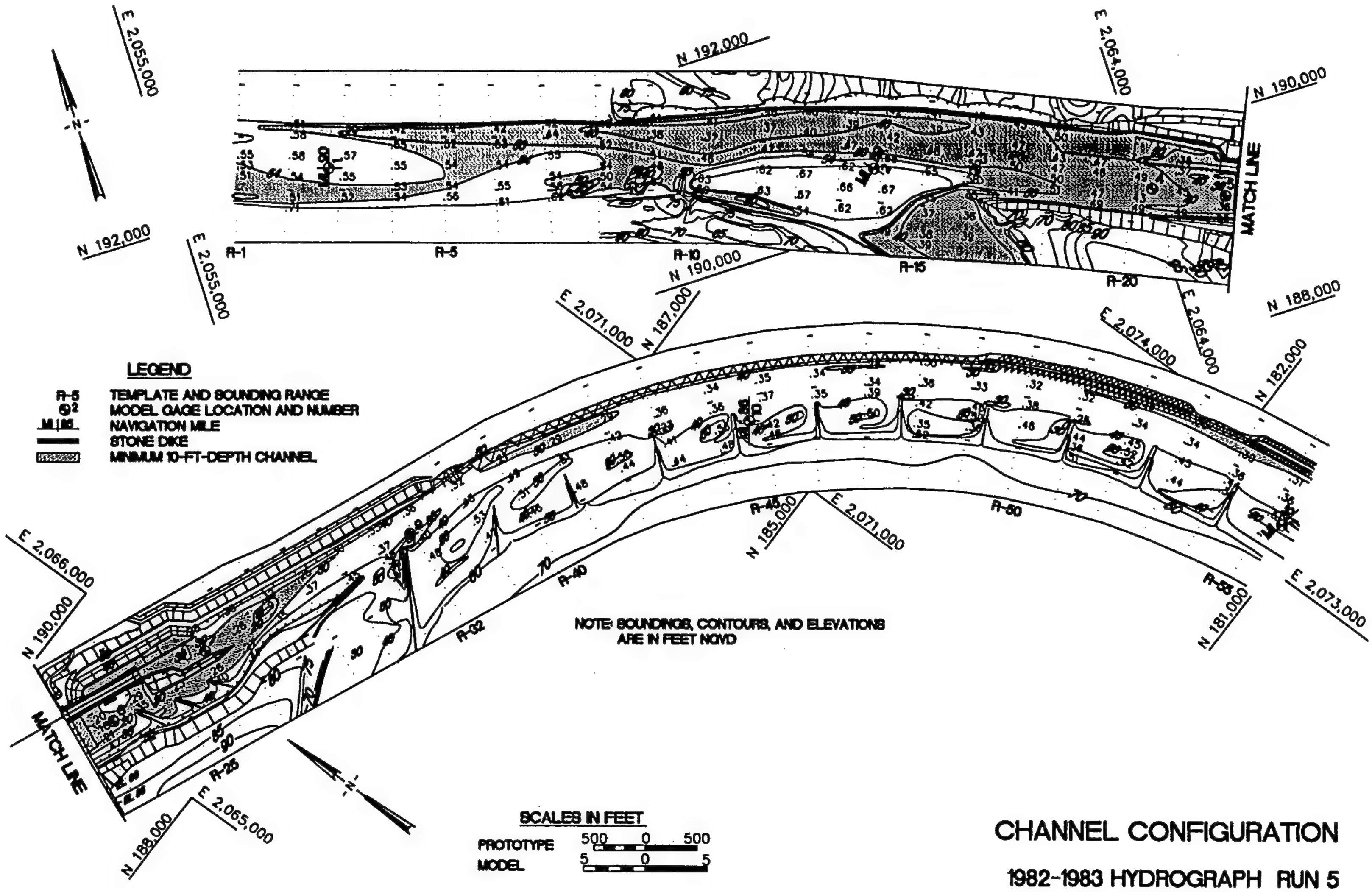
CHANNEL CONFIGURATION

PLAN C-81 T-0 RUN 18



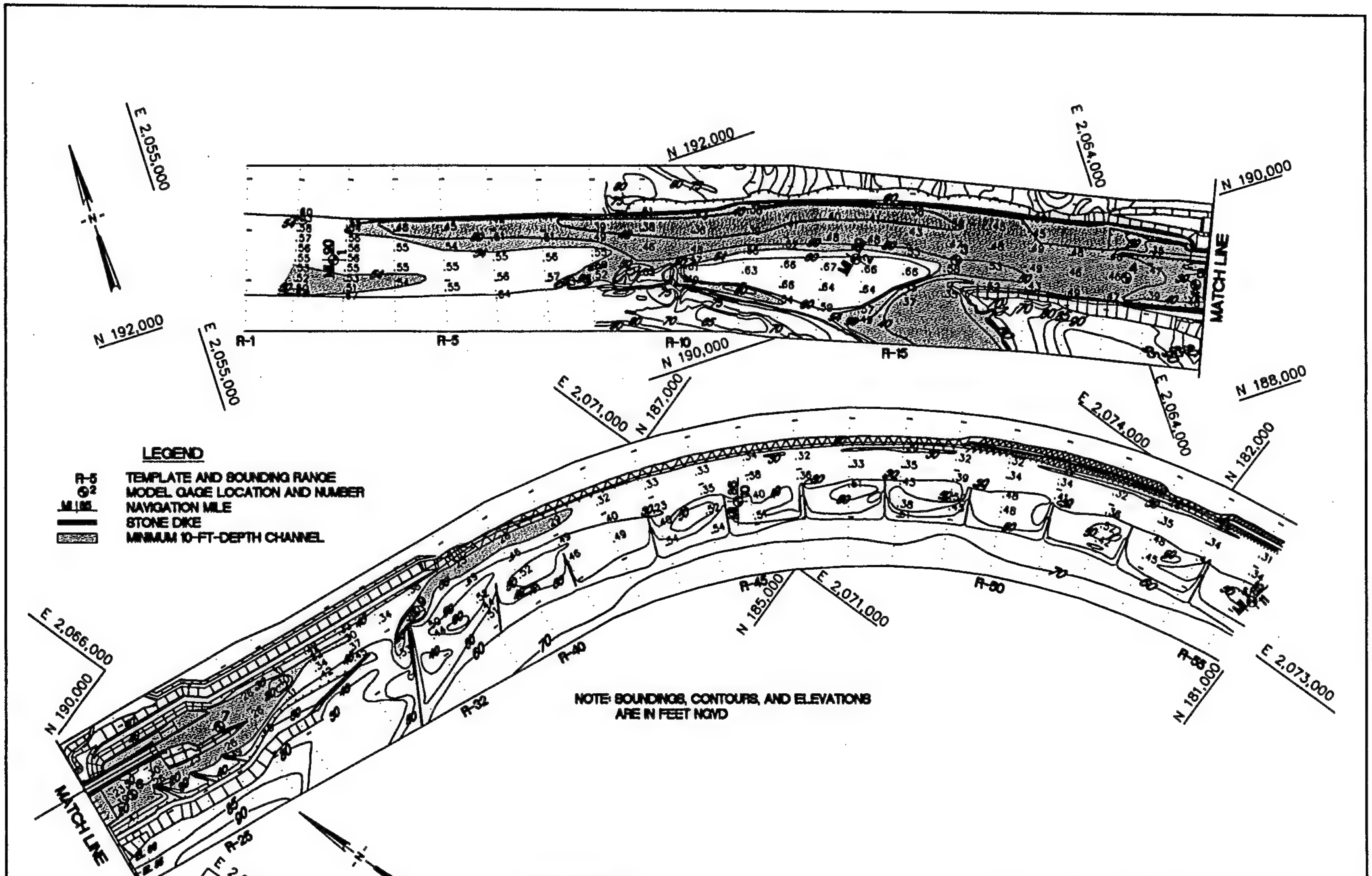
CHANNEL CONFIGURATION

PLAN C81 T-0 RUN 30



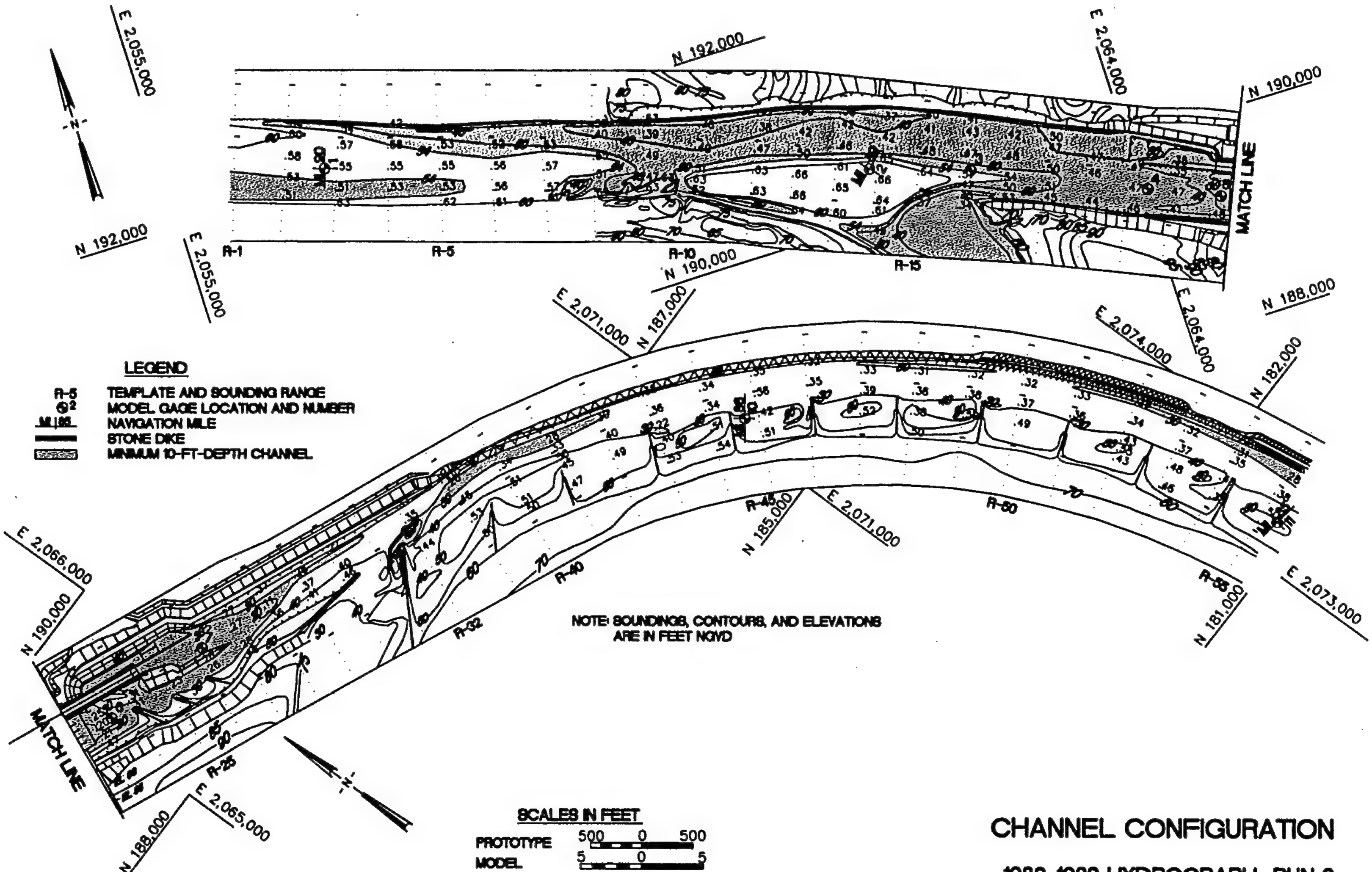
CHANNEL CONFIGURATION

1982-1983 HYDROGRAPH RUN 5



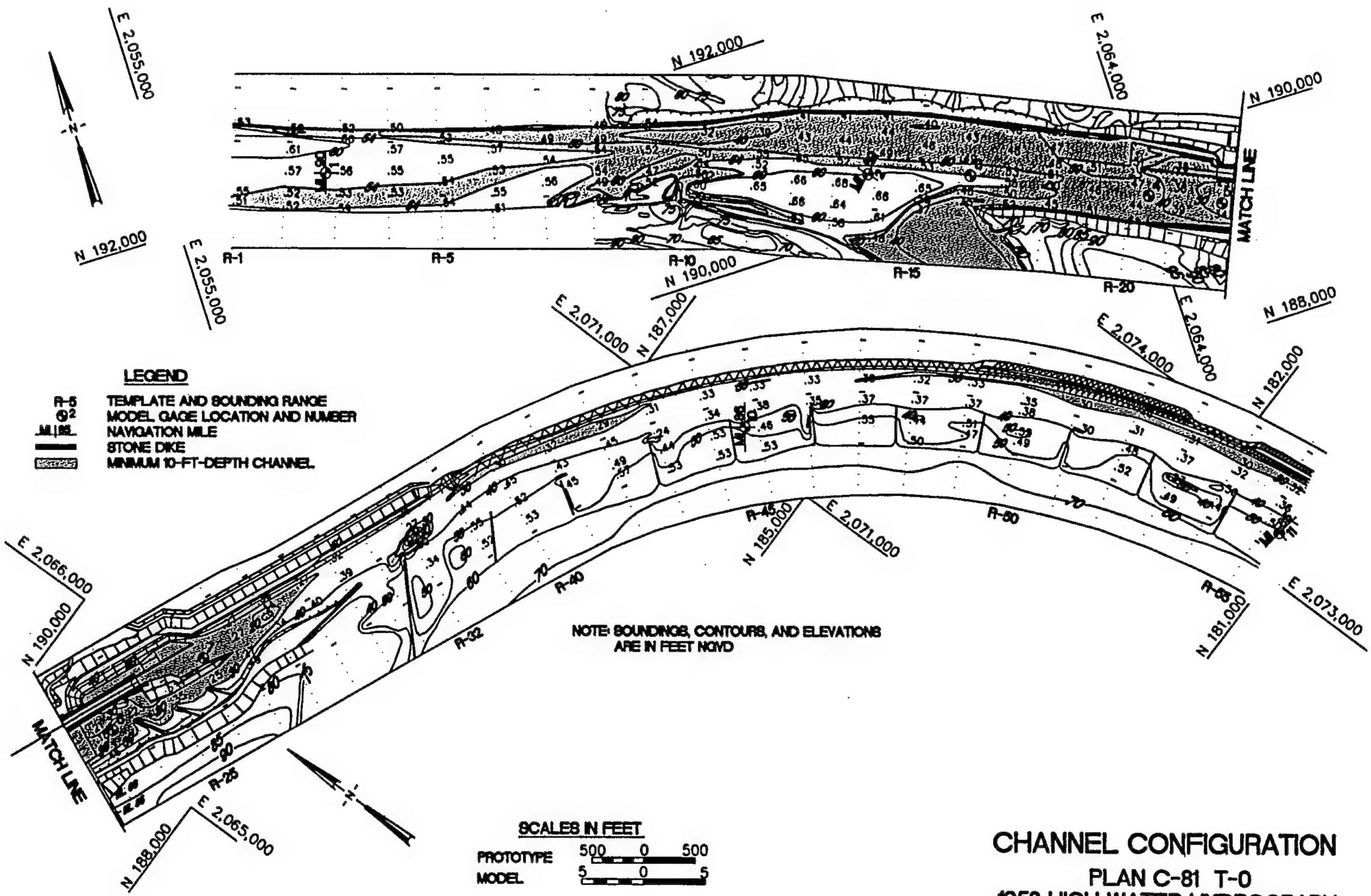
CHANNEL CONFIGURATION

1982-1983 HYDROGRAPH RUN 6

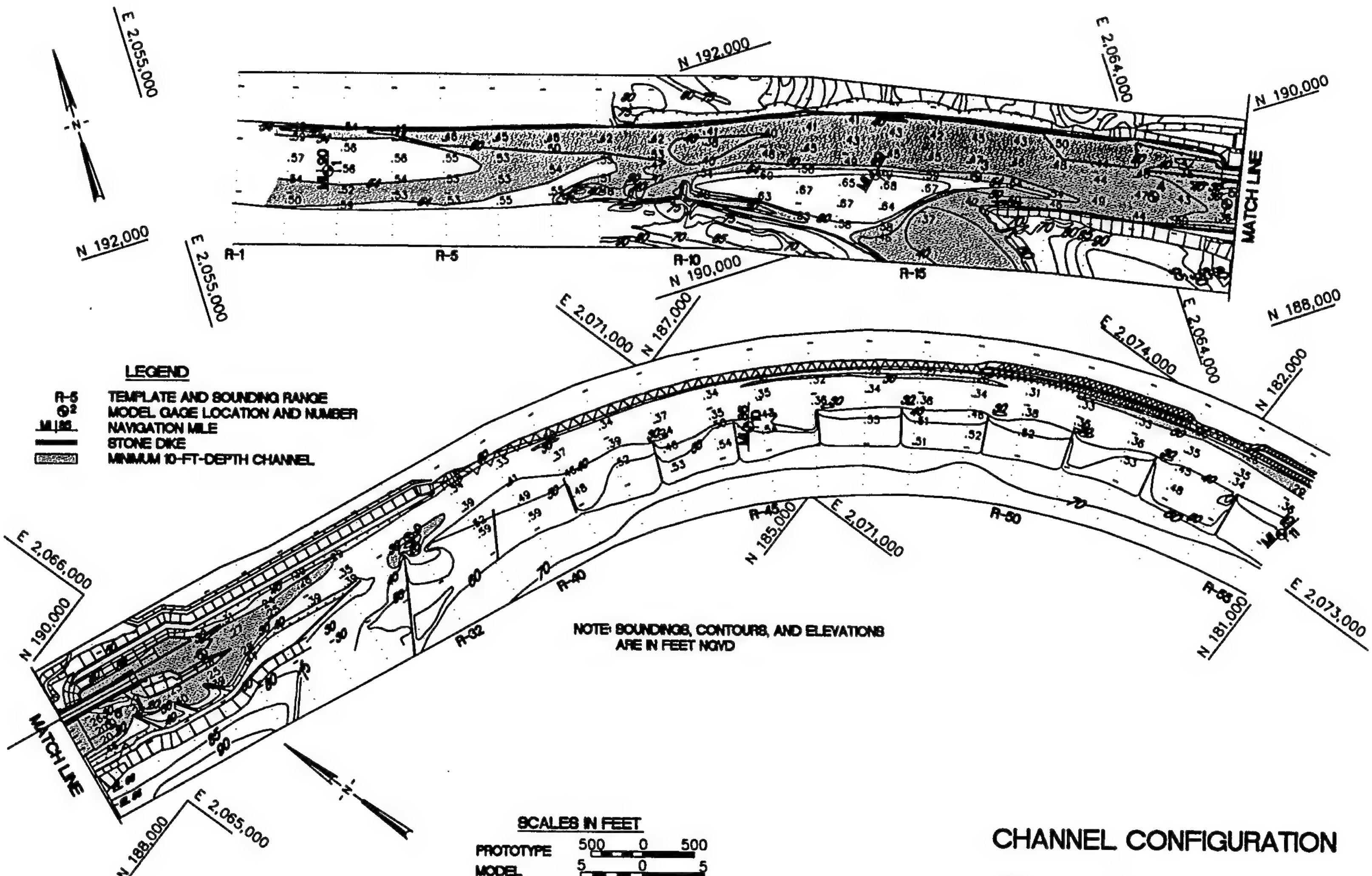


CHANNEL CONFIGURATION

1982-1983 HYDROGRAPH RUN 8

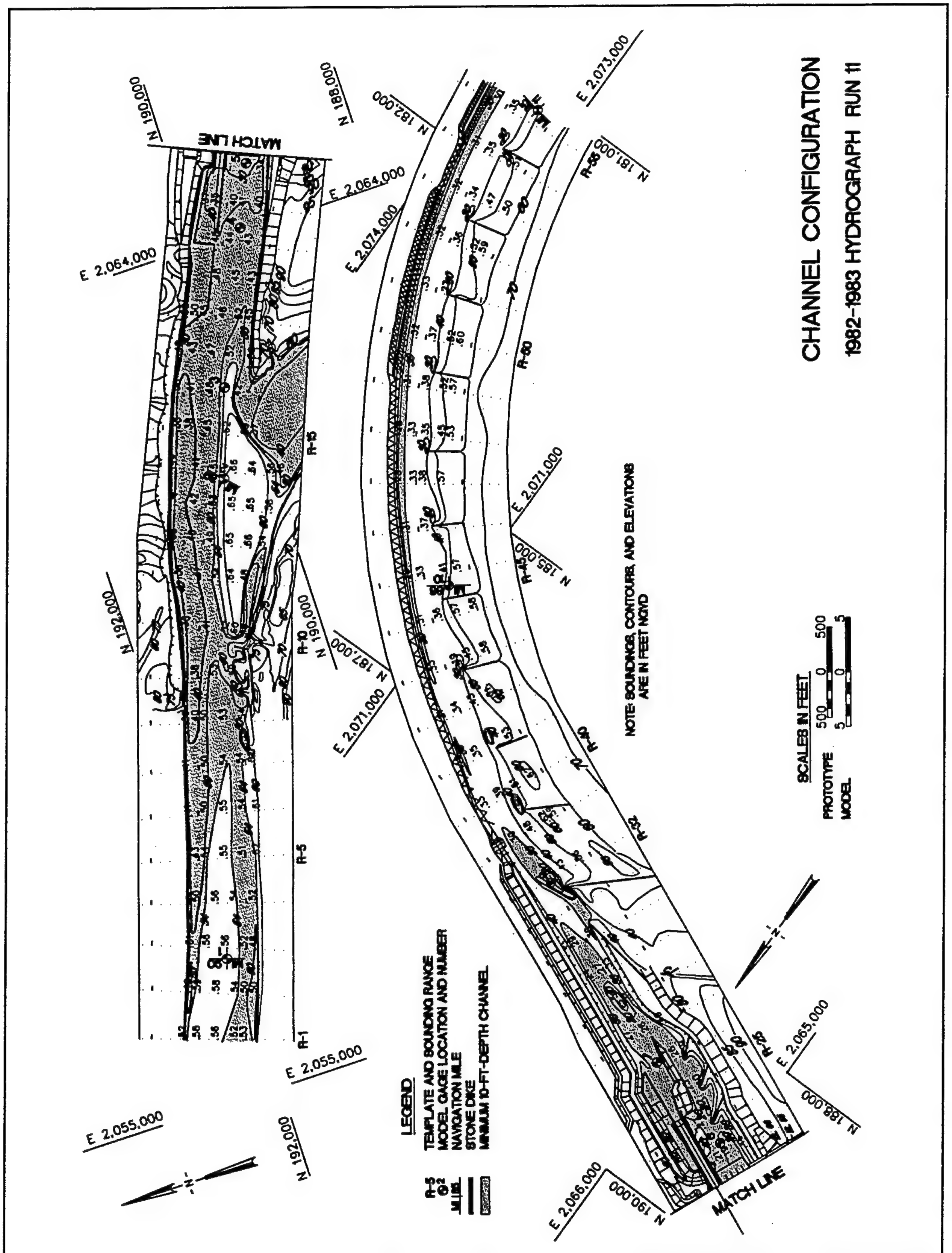


CHANNEL CONFIGURATION
PLAN C-81 T-0
1958 HIGH WATER HYDROGRAPH



CHANNEL CONFIGURATION

1982-1983 HYDROGRAPH RUN 9



CHANNEL CONFIGURATION
1982-1983 HYDROGRAPH RUN 11
LEGEND
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
NAVIGATION MILE
STONE DIKE
MINIMUM 10-FT-DEPTH CHANNEL
NOTE: SOUNDINGS, CONTOURS, AND ELEVATIONS ARE IN FEET NGVD
SCALES IN FEET
PROTOTYPE
MODEL
500
0
500
5
0
5
MATCH LINE
MATCH LINE
N 190,000
N 188,000
N 182,000
N 181,000
N 185,000
N 187,000
N 192,000
N 190,000
N 192,000
N 188,000
N 190,000
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E 2,074,000
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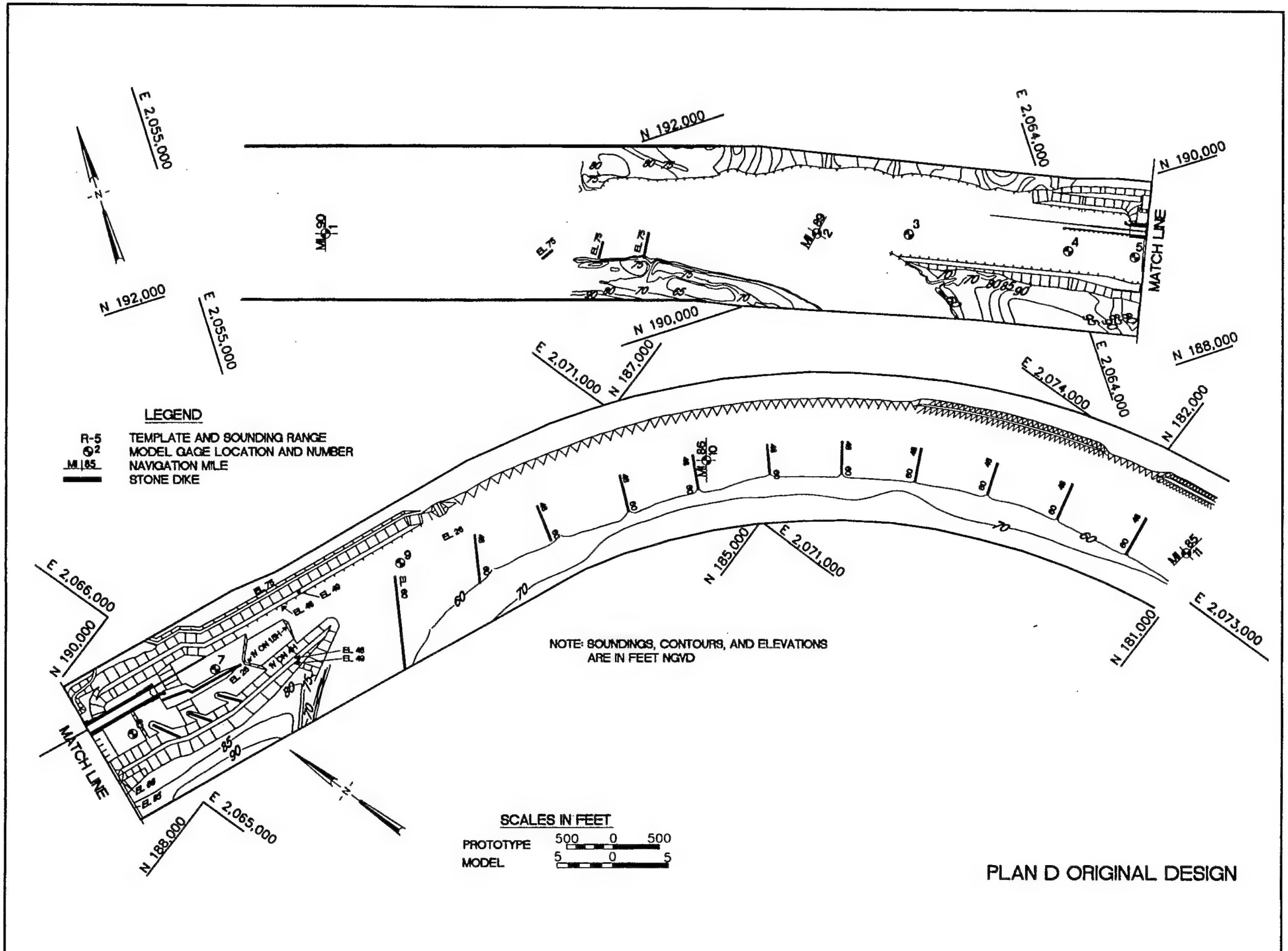
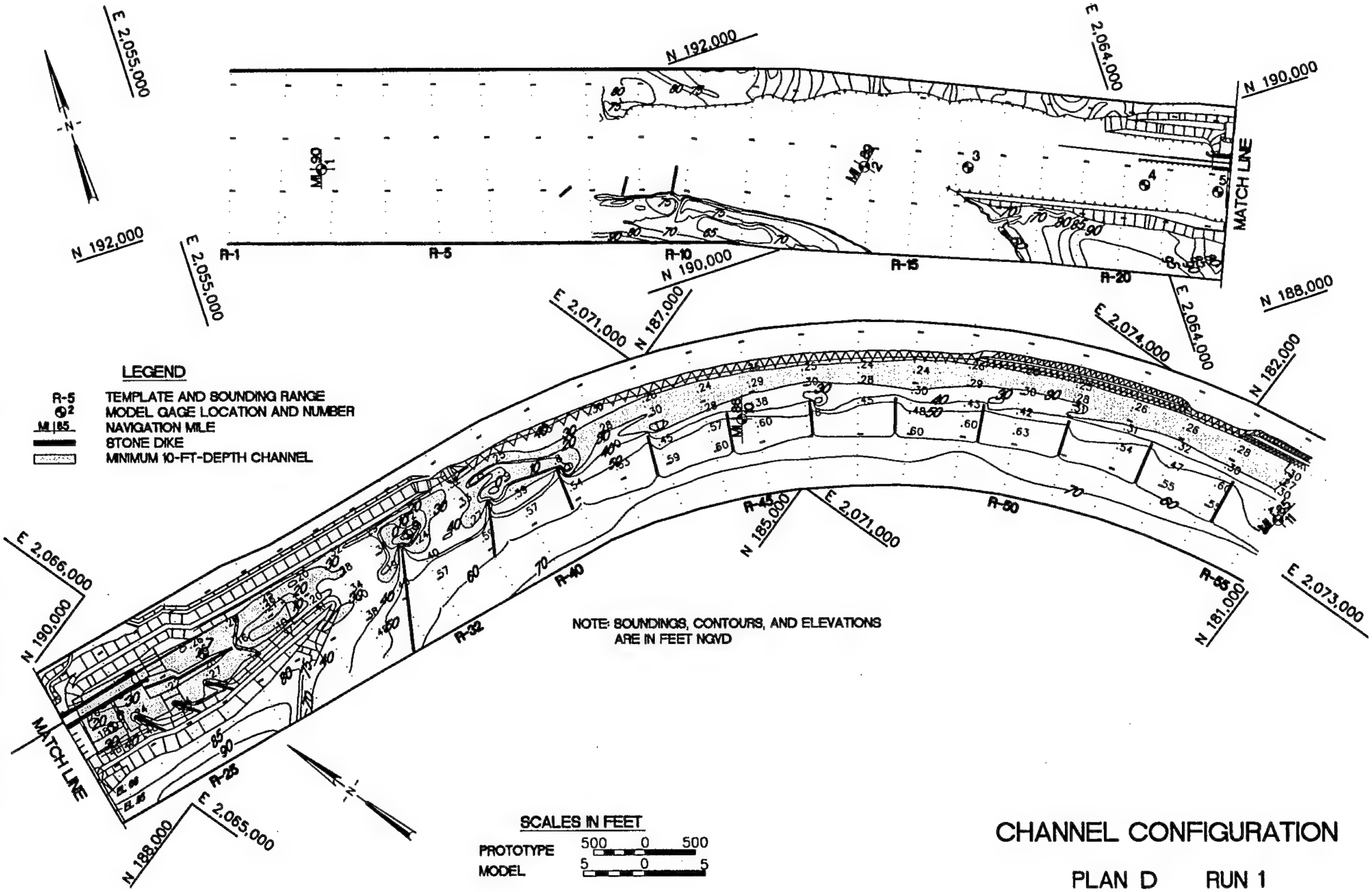
E 2,071,000
E 2,071,000
E 2,055,000
E 2,055,000
E 2,065,000
E 2,066,000
R-1
R-5
R-10
R-15
R-25
R-32
R-40
R-45
R-50
R-55

Plate 44

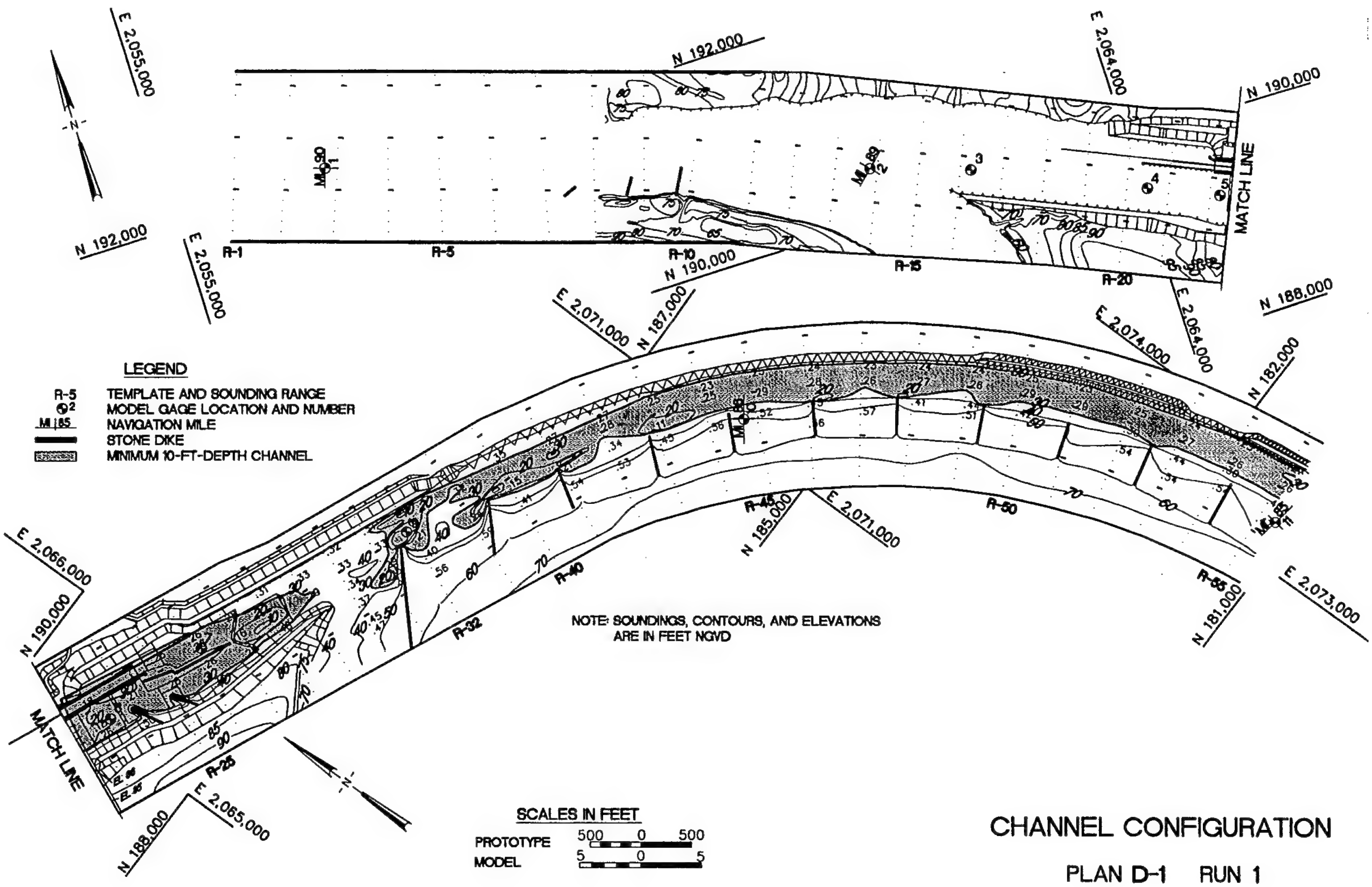


PLAN D ORIGINAL DESIGN



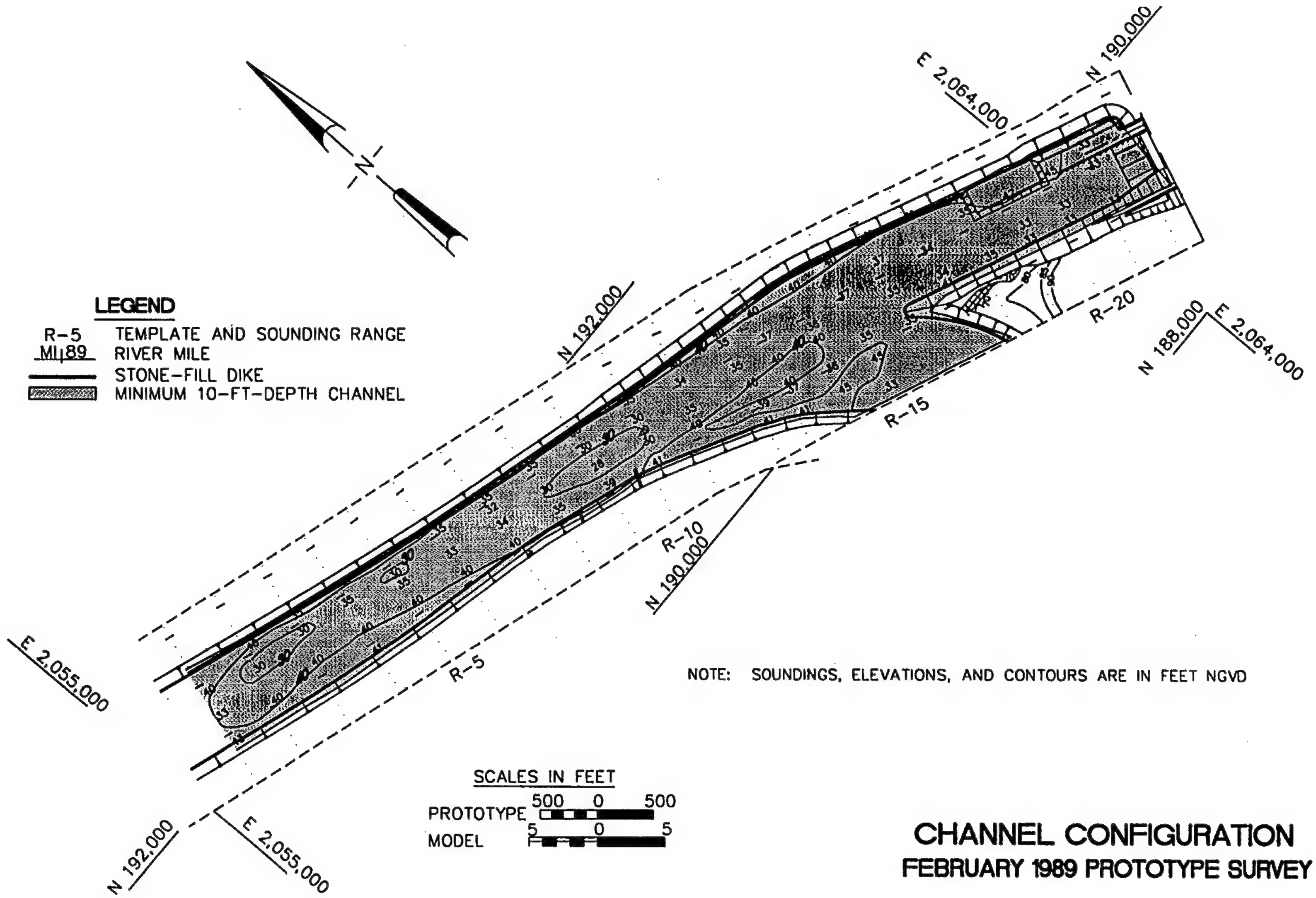
CHANNEL CONFIGURATION

PLAN D RUN 1

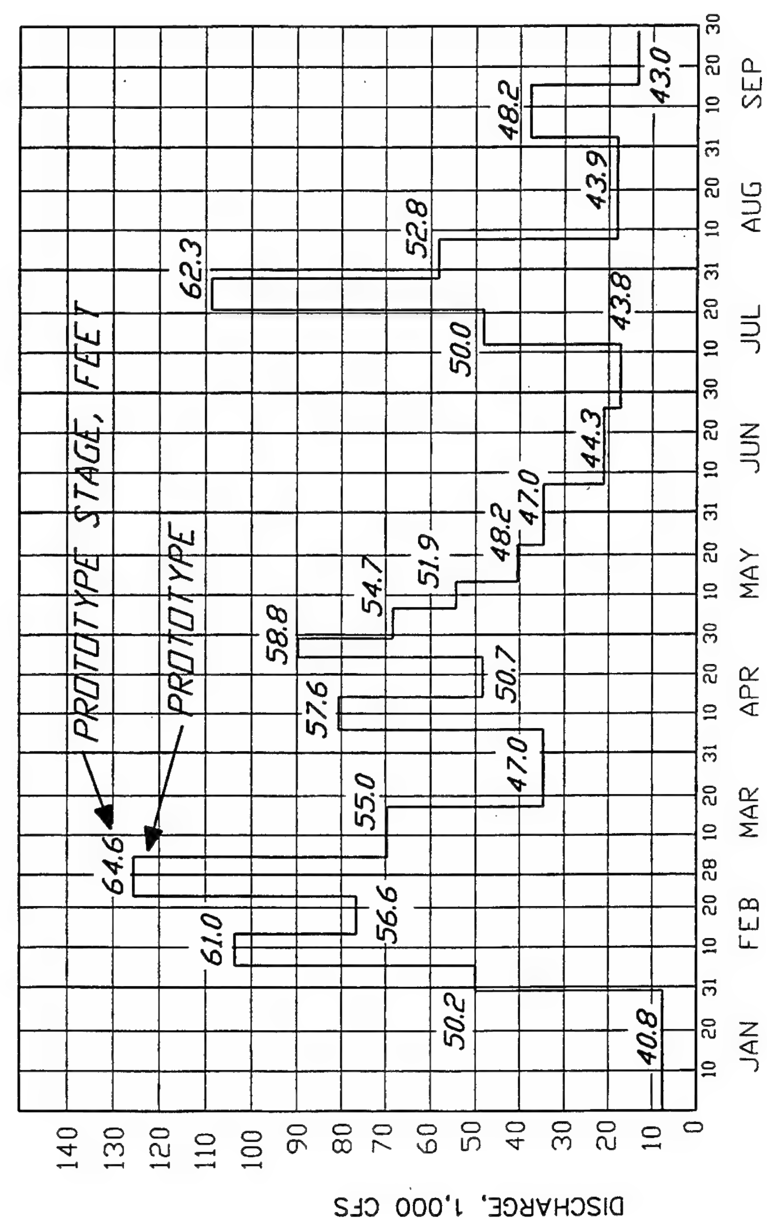


CHANNEL CONFIGURATION

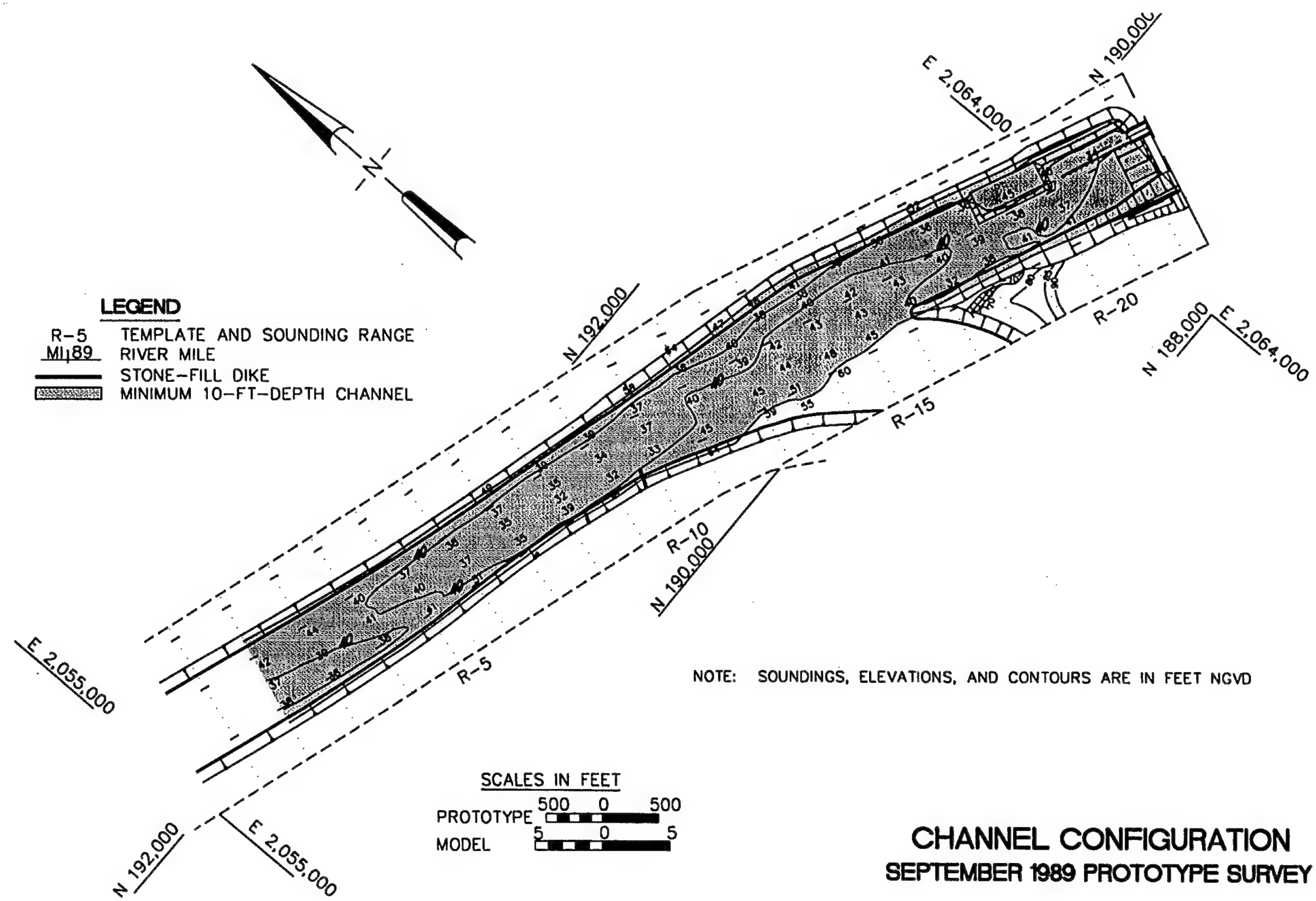
PLAN D-1 RUN 1



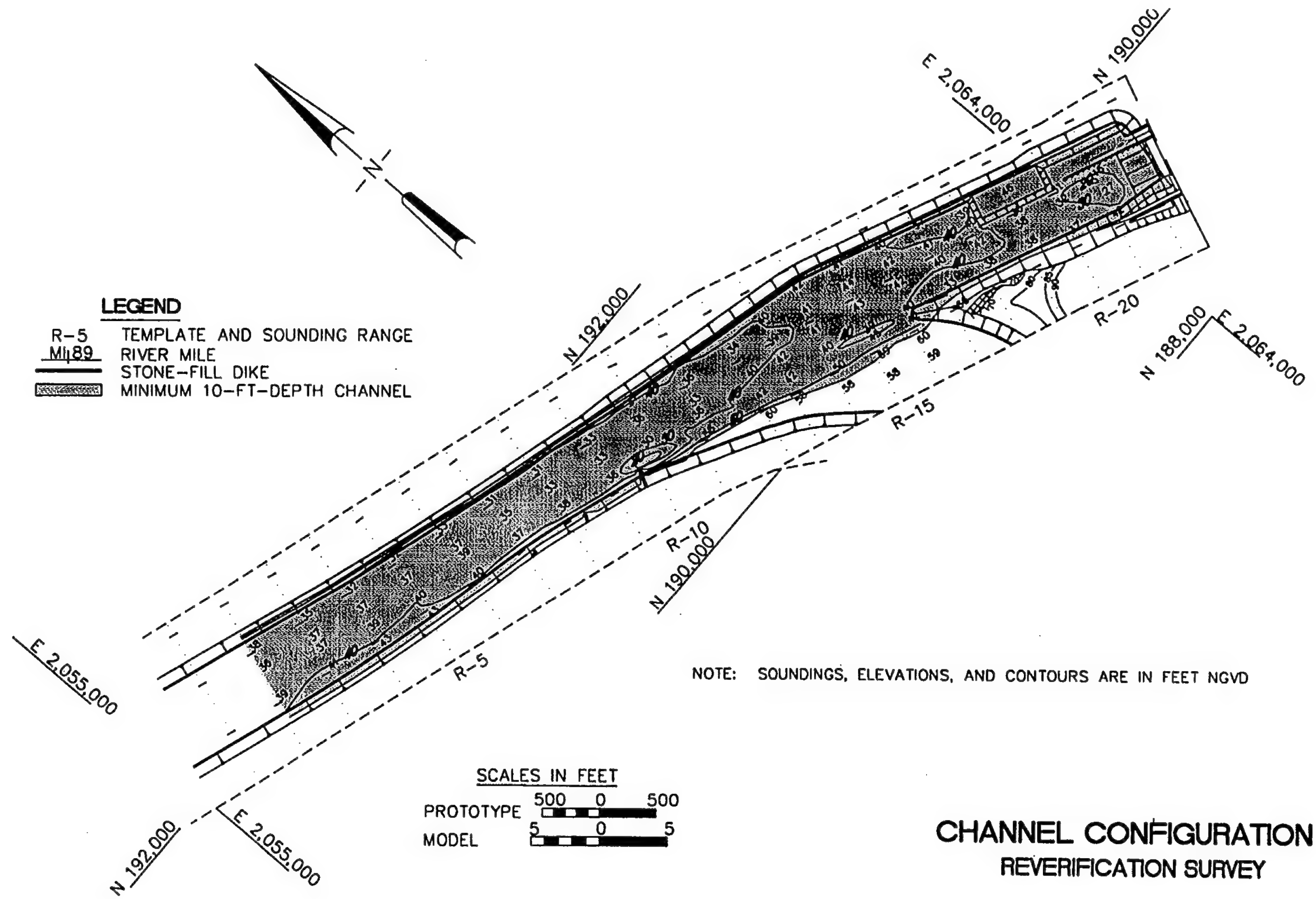
CHANNEL CONFIGURATION
FEBRUARY 1989 PROTOTYPE SURVEY



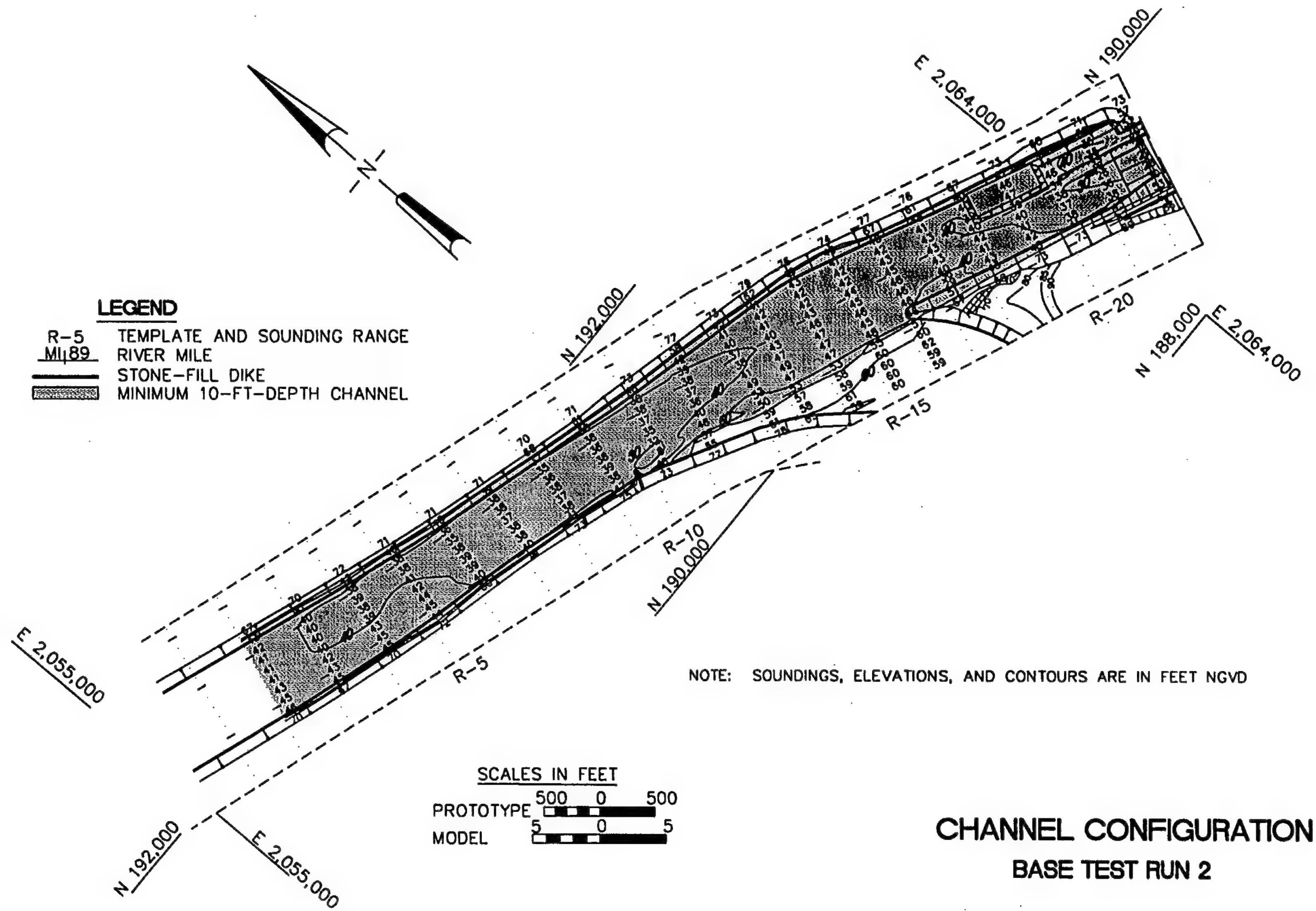
1989 HYDROGRAPH



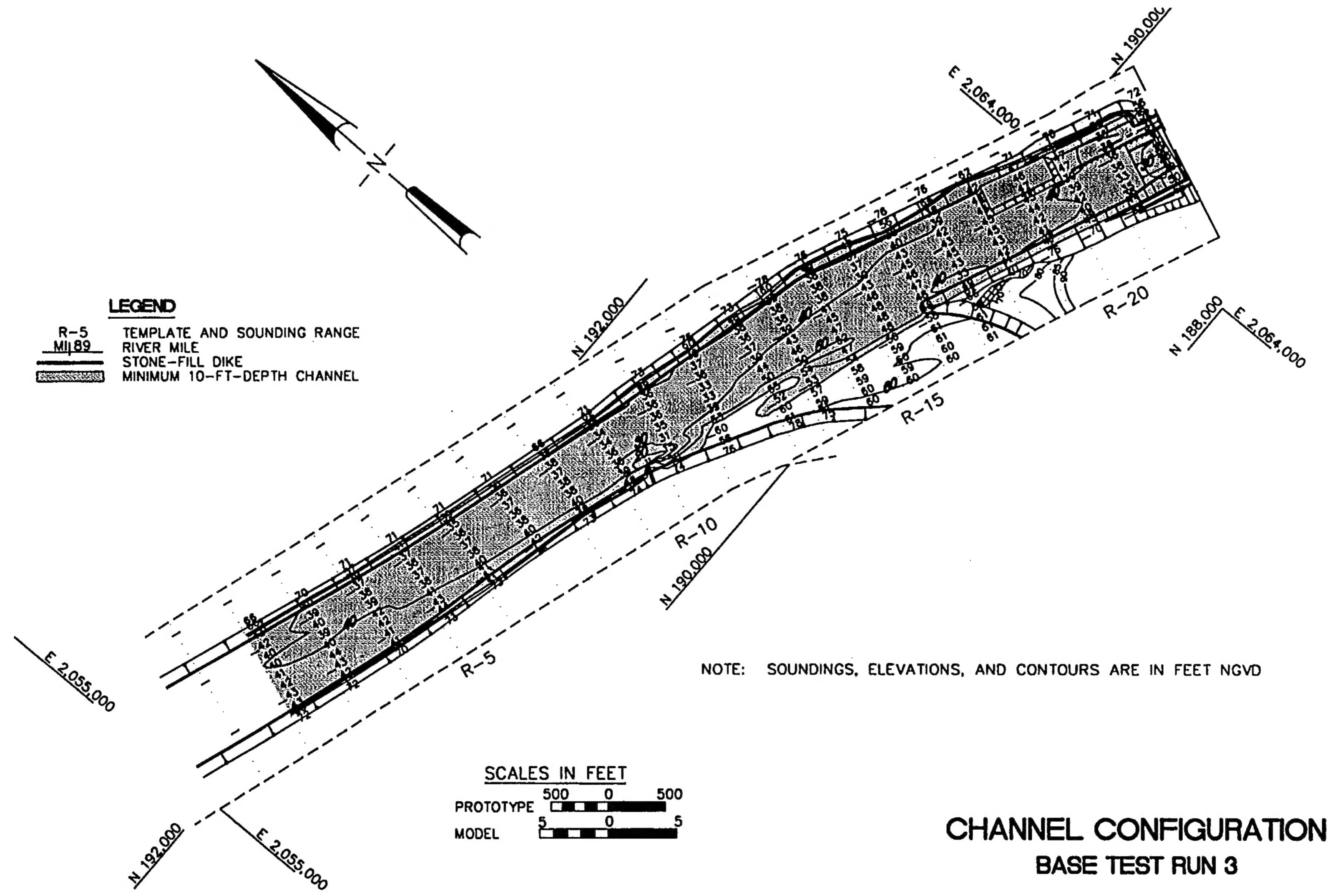
CHANNEL CONFIGURATION
SEPTEMBER 1989 PROTOTYPE SURVEY



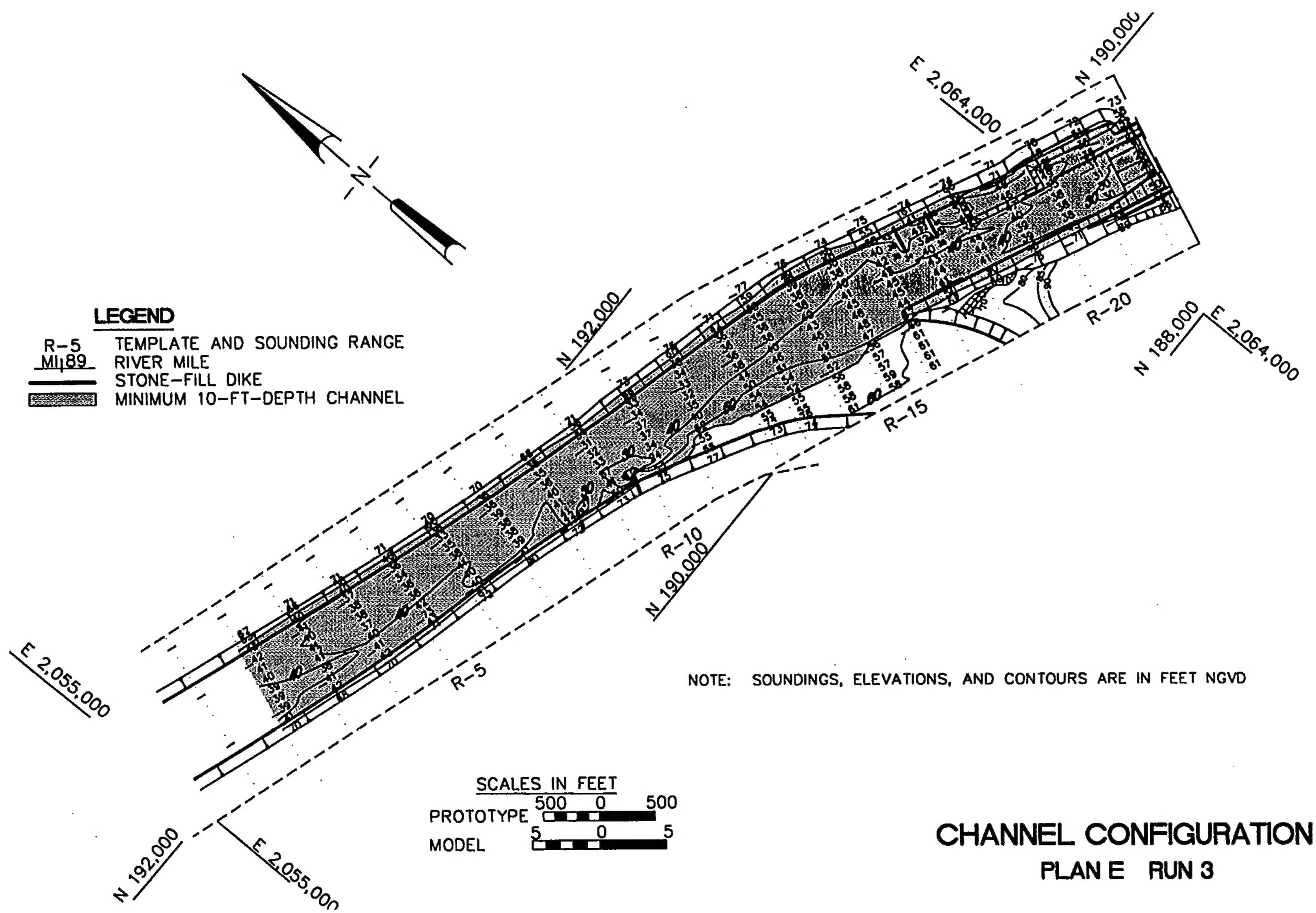
CHANNEL CONFIGURATION
REVERIFICATION SURVEY



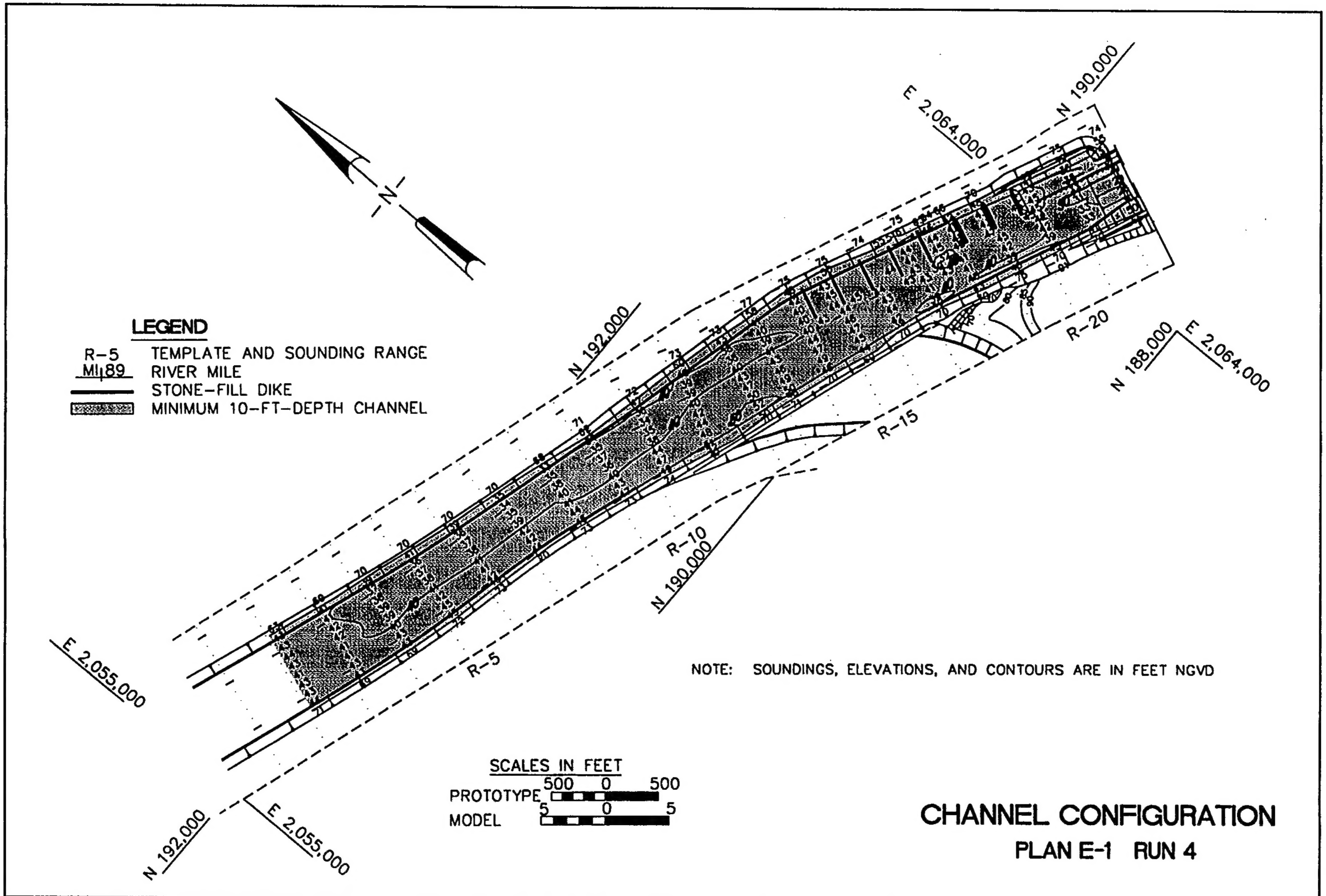
CHANNEL CONFIGURATION
BASE TEST RUN 2



CHANNEL CONFIGURATION
BASE TEST RUN 3



CHANNEL CONFIGURATION
PLAN E RUN 3



CHANNEL CONFIGURATION
PLAN E-1 RUN 4

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Randy A. McCollum

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12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

John H. Overton Lock and Dam, located in a cutoff channel between river miles 89.0 and 86.5 of the Red River, is designed to maintain a normal pool elevation of 64 (all elevations are in feet referred to National Geodetic Vertical Datum) upstream to Lock and Dam 4. The design calls for an 84-ft by 685-ft usable lock chamber and a dam with five 60-ft-wide gates.

A movable-bed model study was performed to determine the alignment of the channel and the arrangement of the lock and dam that would provide the most satisfactory channel for both navigation and sediment movement.

The movable-bed model was built to a scale of 1:20 horizontally and 1:80 vertically and reproduced the study area from river miles 90.0 to 85.0. The movable bed was molded using crushed coal with a median grain size of 4 mm and a specific gravity of 1.30.

The original design for the lock and dam (Plans A and B) used a six-gate dam, maintaining the upper pool at el 58. The dam was redesigned prior to testing of Plan C, going to the final design of five gates, maintaining the upper pool at el 64. Plan C-81 showed a tendency for reduced deposition along the left bank of the upper lock approach. Plan D reduced scour downstream of the lower lock approach, and Plan D-1 also reduced scour but increased deposition along the left bank of the lower lock approach. Plan E prevented shoaling in the upper lock approach, and Plan E-1 would likely increase shoaling compared with the Base Examination conditions.

14. SUBJECT TERMS

Dam	Navigation
Lock	Red River
Model	Sediment
Movable-bed model	Shoal

15. NUMBER OF PAGES
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UNCLASSIFIED	UNCLASSIFIED		